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VOLUME 23 MARCH, 1949 NUMBER 2

LOUISIANA CANE RIVER EOCENE FORAMINIFERA

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ABSTRACT—The lithologic characters of the Cane River formation are described and these strata are correlated with corresponding formations in Texas and Mississippi. Out of a foraminiferal fauna of 133 species and varieties noted in the Cane River formation, 78 new species, 1 new variety, and 6 previously named species are described and illustrated.

INTRODUCTION

THE Cane River formation comprises the beds included between the overlying Sparta sands and the underlying Sabine group. The stratigraphic extent, the lithologic content and the fossil assemblage of this formation have been only briefly dealt with.

The formation was originally described by W. C. Spooner (1926) as follows:

Cane River Beds—In the Cane River are included the 75–150 feet of beds above the Wilcox formation and below the massive Sparta sand. The name Cane River, from the excellent exposures on Cane River at Natchitoches, Louisiana, was suggested by H. V. Howe.

These beds outcrop in a narrow belt trending northeast across southern Sabine and Natchitoches parishes. A few miles east of Red River the strike changes to northwest, and continues in that direction to the Arkansas line. The width of the outcrop is 3–7 miles.

An erosional unconformity separates the Cane River and Wilcox beds. The basal member consists of glauconitic sand and sandy clay, but in some places marine tuff is present at the base. Glauconitic clays predominate in the southern portion of the outcrop, but northward from Bienville Parish they become sandier, until, in northern Bossier Parish, they are represented entirely by sands, in part glauconitic, and containing a meager representation of the prolific fauna found farther south. The fauna of the Cane River beds have been described by Harris [1919] and Vaughan [1900]. Harris groups the fauna under the St. Maurice and Claiborne stage, and Vaughan makes the following statement concerning these beds; "For Alabama, Mississippi, and Louisiana, excepting Natchitoches, the species are very nearly the same in all of these stages for this division of the Claiborne, and apparently all belong to that horizon of the Lower Claiborne called the Lisbon beds." Vaughan lists the following species typical of the Cane River beds from Natchitoches, Louisiana: *Amphihelia natchitoensis* Vaughan, *Madracis ganei* Vaughan, *Endopachys maclurii* (Lea), *Balanophyllia augustensis* Vaughan.

From this statement it is obvious that Vaughan recognized a faunal province distinct from the remainder of the Lower Claiborne.

The Cane River beds, as shown in records of wells drilled east and southeast of the outcrop, are made up chiefly of glauconitic clays with subordinate beds of sand. The thickness increases slightly in the eastern and southeastern parts of the salt-dome region.

The following quotation is H. K. Shearer's (1930) description of the Cane River formation:

Cane River fm. (*Eocene*).—The name Cane River fm., derived from Cane River near the city of Natchitoches, is now in general use for the

lower marine beds of the Claiborne group. The formation may be divided into two members, the Cane River clay above and the Cane River marl below.

The top member is sandy shale, which grades downward into smooth, plastic, slightly calcareous clay-shale. This material is characterized by its choc.-brown color, generally specked and streaked with light green. It is all marine, and Foraminifera are plentiful.

The lower member consists of fossiliferous sandy, highly glauconitic marl or soft limestone. It is commonly logged as "salt and pepper sand," because of the appearance of the white limestone with grains of dark glauconite.

The thickness of the Cane River ranges from about 333 ft. in The Texas Company's Tensas Delta No. B-1, to more than 500 feet, becoming thicker toward the southeast. The Texas Company's Harris-Hyman No. 1 was drilled 537 feet into the Cane River without passing through it, but this well was evidently very near the base of the formation when abandoned.

The thickening is principally in the lower marl member. At the Standard Oil Company's Tensas Delta No. 1, where no marl was recognized in drilling and only a few fragments were found in the cuttings, the thickness correlated as Cane River is only 401 feet, increasing about 80 feet in 3 miles southeast to the Lochnager Oil and Gas Company's McMillan No. 1, where the lower marl is approximately 30 feet thick. Such local variations are evidently due to an erosional unconformity which left small hills in the Wilcox surface on which the Cane River formation was laid down.

In a paper on correlation of the Claiborne, A. C. Ellisor (1929) defined and described the Cane River of Texas as follows:

Cane River.—The lithology of the Cane River as limited in this paper is a glauconitic, sandy marl and a glauconitic, clayey sand. *Ostrea sellaeformis* var. *lisbonensis* Harris and *Orthophragmina advena* Cushman characterize the Cane River member. The type locality is at Badin Hill on Cane River, ½ mile north of Natchitoches, Louisiana. Excellent exposures of the Cane River member are found within the town of Natchitoches, at Victoria Mills, 2.1 miles north of Provencal; and ½ mile west of Provencal in Natchitoches Parish, Louisiana. The Cane River member occurs stratigraphically above the Wilcox formation and below the Reklaw member in Louisiana.

The above correlation is incorrect. It is now recognized that the Cane River lies above, or at best is partially equivalent to the Reklaw member. It most certainly does not lie below the Reklaw.

Other papers of significance which have mentioned the beds of Cane River age are one by G. D. Harris and A. C. Veatch (1899), in which is presented one of the earliest descriptions of the beds at the type locality near Natchitoches, Louisiana; one by C. L. Moody (1931), which briefly describes some of the structural expressions of the Cane River beds around the Sabine uplift; and one by H. V. Howe (1936), which briefly discusses the economic possibilities of the Cane River formation. K. M. Hussey (1942) in a short paper described the more distinctive members of the foraminiferal fauna.

On the basis of stratigraphic, lithologic and paleontologic evidence, the strata which most closely correlate with the Cane River beds of Lousiana are in my opinion the Enterprise green marl of Mississippi and the Weches greensand of Texas.

The following quoted description of the Enterprise green marl by E. N. Lowe (1915), serves to identify the Mississippi equivalent of the Cane River:

The materials of the Lisbon formation consist in the lower parts of marine marls and calcareous sands, in the upper parts very largely of lignitic clays and lignite.

The lower member we have named the Enterprise Green Marl, from the town of Enterprise in Clarke County, where it is well exposed. This member is composed principally of fossiliferous marl beds that vary in color from light gray to dark green, the depth of color being largely determined by the relative proportions of glauconite, or greensand. The lighter colored marls are highly calcareous and often clayey, showing abundant evidences of comminuted shells. The dark green marls, however, are also highly fossiliferous, fish teeth, oyster shells, sea urchins, and numerous other fossils being abundantly found . . . .

. . . On the Chickasawhay half a mile below Enterprise the green marl becomes indurated and forms a bluff 12 feet high on the east side of the river. This indurated bed shows abundant flat sea urchins, called *Scutella lyelli*, as well as oysters, shark's teeth, and other fossils . . . .

. . . Three miles east of Newton a cut on the A. & V. Railroad shows abundance of the large saddle-shaped oyster, *Ostrea sellaeformis*, so characteristic of this division of the Claiborne.

At present (Thomas 1942) the Enterprise is restricted to the greensand marl bed in the lower part of the Winona sand which is upper Tallahata in age.

The Weches of Texas was named by Wendlandt and Knebel (1929) and described as a remarkable deposit of rather pure glauconite with an average thickness of approximately 50 feet, but thicker in Nacog-

doches and San Augustine Counties. A. C. Ellisor (1929) also described the member as the massive greensand bed below the Sparta sand member and above the Queen City sand member, but did not think it correlated with the Cane River of Louisiana. The following section given by Renick and Stenzel (1931) is one of the most complete published to date and is quite similar to the Cane River section given in this paper:

Gray clay with laminae of buff glauconitic clay. locally grades into sand, marine.
±20′

Concretionary ironstone bed, buff glauconitic clay with local beds of glauconitic marl.
±10′

Argillaceous limestone and glauconitic marl, very fossiliferous, buff and gray glauconitic clay, marine.
+25′

Fossiliferous glauconitic sand, buff and gray glauconitic clay.
±10′

My detailed study of numerous surface samples and well cores fails to support the present general concept that the Cane River beds of Louisiana are entirely the equivalent of the Weches and Reklaw members of the Mt. Selman group of Texas. The only striking departure from a typical Weches lithology found in the Cane River beds is the chocolate-brown to gray shale member. No Reklaw equivalent is recognized.

In brief, the lithology of the formation is such as to allow a threefold division. The upper part is a chocolate-brown to gray-brown lignitic shale. The middle division is composed of a glauconitic marl which grades downward into the third division, a glauconite and quartz sand with thin shale partings.

Through rare good fortune a continuous set of cores, representing every inch of what is generally recognized as the Cane River formation, was obtained. A careful lithological as well as paleontological study of those cores furnished the information on which the following section is based, and revealed that there is a transition zone both above and below the Cane River as was suggested by H. N. Fisk (1938) and J. Rukas (1939) from evidence obtained by them in their survey of Grant and LaSalle, and of Natchitoches parishes, La. Thus it is difficult to state exactly how thick the Cane River formation is, in that there are no definite Sparta-Cane River, or Cane River-Wilcox contacts. For the purposes of this paper the fossiliferous zone lying between the relatively unfossiliferous overlying Sparta and underlying Wilcox sands is the Cane River formation. One must bear in mind, however, that this same definition does not hold down-dip, as both the Sparta and the Wilcox become fossiliferous in their down-dip facies. However, the Cane River fauna is distinct enough so that it should serve to delimit the formation even though it lies between two equally fossiliferous formations.

C. M. Bowers et al. E. T. Morrison No. 1, 1436′–1656′, S 24, T 9 N, R 1 W, Grant Parish, La.

Transition zone of lignitic sands and shales very sparingly fossiliferous, thickness varying from less than 10 to over 100 feet.

Gray-brown to chocolate-brown lignitic silty shale with glauconitic content increasing with depth, very fossiliferous, characterized by *Cyclammina caneriverensis*
approx. 24 feet

Gray-green to dark-green shale containing pockets of greensand, very fossiliferous, *Lamarckina claibornensis*
approx. 10 feet

Greensand marl with siltstone and shale partings, becoming more sandy with depth, very fossiliferous, *Discocyclina advena*
approx. 31 feet

"Salt and pepper" sand with well developed green shale partings and thin gray-green siltstone beds, considerable pyrite in lower part, becoming more quartzose with depth, fossiliferous, *Bifarina turriformis* in upper part, *Asterigerina texana* prolific in lower few feet.
approx. 29 feet

Lower transition zone

Non-fossiliferous, lignitic, slightly glauconitic quartz sand, considerable pyrite and mica
7 feet

Fossiliferous gray-brown silty shale, some sand and glauconite, fauna similar to that in upper shale member of formation
3 feet

Non-fossiliferous lignitic, pyritic, micaceous sand with very little shale
2 feet

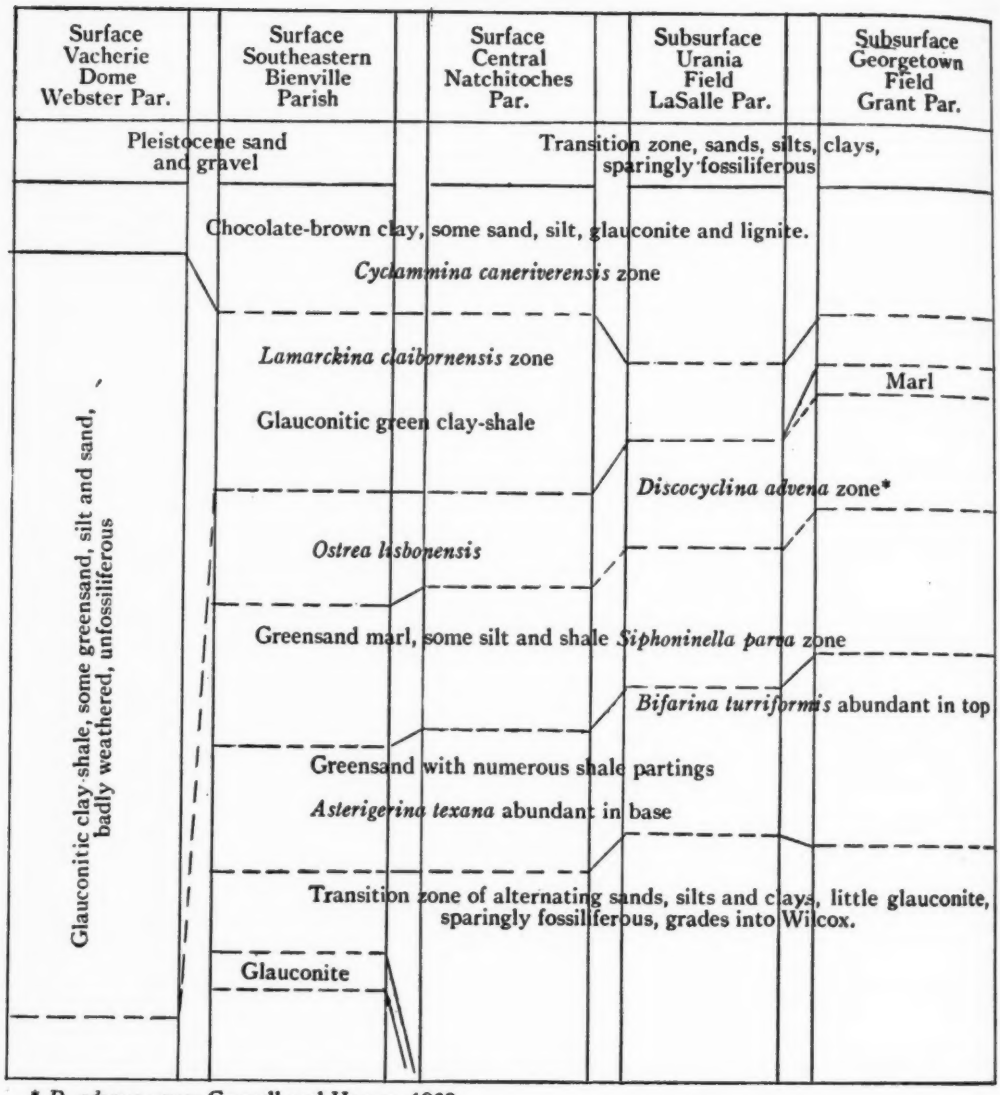
Fossiliferous, gray-brown, lignitic shale, some glauconite, and quartz sand
4 feet

Tough gumbo-shale, some glauconite, quartz sand, lignite, and mica, cuttings from here to bottom of well
64 feet

Total thickness of transition zone present in well
80 feet

The accompanying correlation chart is an attempt to show the relationships of surface to subsurface lithologic divisions of the Cane River. The surface section from Natchitoches

CORRELATION CHART


Surface Vacherie Dome Webster Par.
Surface Southeastern Bienville Parish
Surface Central Natchitoches Par.
Subsurface Urania Field LaSalle Par.
Subsurface Georgetown Field Grant Par.
Pleistocene sand and gravel
Transition zone, sands, silts, clays, sparingly fossiliferous
Chocolate-brown clay, some sand, silt, glauconite and lignite.
Cyclammina caneriverensis zone
Lamarckina claibornensis zone
Marl
Glauconitic green clay-shale
Discocyclina advena zone*
Ostrea lisbonensis
Greensand marl, some silt and shale Siphoninella parva zone
Bifarina turriformis abundant in top
Greensand with numerous shale partings
Asterigerina texana abundant in base
Transition zone of alternating sands, silts and clays, little glauconite, sparingly fossiliferous, grades into Wilcox.
Glauconitic clay-shale, some greensand, silt and sand, badly weathered, unfossiliferous
Glauconite

* *D. advena* zone; Gravell and Hanna, 1938.

Parish is composite, made from a study of the Badin Hill (type locality) exposure and from information supplied by J. Rukas (1939), who has recently completed a survey of the parish. The surface section from Bienville Parish is also composite, made from a careful study of the Prothro dome exposure, and from information supplied by Dr. R. Dana Russell, who is completing a survey of that parish. The subsurface sections are considerably more accurate in that they were made from very completely cored Cane River sections from wells in Grant and LaSalle parishes. The chart shows how much the lithology of the formation changes from north to south and how little the change is from east to west. The significant fact connected with the expected thinning of the formation to the northwest is that the thinning is almost entirely at the expense of

the marl member. The rest of the formation becomes much more sandy. That lithologic change seems to indicate nearness of the old Cane River shoreline, landward of which one could not expect to differentiate the Cane River beds from either the overlying Sparta or the underlying Wilcox sands.

A study of the paleontology and lithology of the Cane River formation brings out ecological matters of considerable interest. For instance, many of the species which occur quite abundantly in the lower clay member of the formation are not found in either the marl or greensand members above, but many of them reappear in thin chocolate-brown clay beds above the marl member. Also, there are some species which occur only in the marl or, abundantly, only in the greensand members. Thus the ecological relationship of the fauna to the type of sediment permits even a better zonation than can be made on lithology alone.

The following distinctive species serve to zone the Cane River in Louisiana wherever comparable ecological conditions existed during the time the formation was deposited.

Cyclammina caneriverensis Hussey, *Quinqueloculina gibbosa* Hussey, *Quinqueloculina striaturata* Hussey — Upper, chocolate-brown member

Marginulina variata Hussey — Abundant in marl and upper shale member

Bifarina turriformis Hussey, *Lamarckina claibornensis* Cushman, *Discocyclina advena* — Marl member

Asterigerina texana (Stadnichenko) — Abundant only in lower part of greensand member

There are several other good index fossils in the formation, but these are the most distinctive and persistent.

A few papers have described partial faunas of formations outside Louisiana that are correlated with the Cane River. J. A. Cushman and N. L. Thomas (1929) reported the following species from the Cook Mountain and Mt. Selman formations of Texas:

Textularia cf. *mississippiensis* Cushman
Guttulina irregularis (d'Orbigny)
Sigmomorpha (*Sigmomorphina*) *pseudoregularis* Cushman and Thomas
Ceratobulimina eximia (Rzehak)
Eponides guayabalensis Cole
Lamarckina claibornensis Cushman
Siphonina claibornensis Cushman
Asterigerina texana (Stadnichenko)

In a subsequent paper Cushman and Thomas (1930) noted the following additional species from these formations:

Quinqueloculina yeguaensis Weinzierl and Applin
Triloculina trigonula (Lamarck) (1804)
Discorbis yeguaensis Weinzierl and Applin
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna
Cibicides sassei Cole

Cushman and Ellisor (1933) described *Textularia smithvillensis* from the (Claiborne) Weches outcrop at Smithville, Texas.

E. H. Sellards, W. S. Adkins and F. B. Plummer (1932) listed *Asterigerina texana* (Stadnichenko) (1927), from the (Claiborne) Weches of Texas.

H. V. Howe (1939) monographed the Foraminifera of the Cook Mountain formation of Louisiana. After a complete check of the included species, the author found the following also present in the Cane River formation.

Ammodiscus incertus (d'Orbigny)
Ammobaculites mauricensis Howe
Dentalina winniana Howe
Nodosaria vertebralis (Batsch)
Lagena ouachitaensis Howe and Wallace
Lagena fenestrissima Howe and Ellis
Lagena striata (d'Orbigny) var. *strumosa* Reuss
Guttulina austriaca d'Orbigny
Guttulina irregularis d'Orbigny
Globulina gibba d'Orbigny
Sigmoidella plummerae (Cushman and Ozawa)
Nonion micrum Cole
Nonion planatum Cushman and Thomas
Nonionella mauricensis Howe
Nonionella winniana Howe
Gümbelitria columbiana Howe
Bulimina robertsi Howe and Ellis
Bitubulogerina ellisi Howe
Bolivina taylori Howe
Loxostoma claibornense Cushman
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna
Ceratobulimina eximia (Rzehak)
Pulvinulinella exigua (H. B. Brady) var. *obtusa* (Burrows and Holland)
Siphonina claibornensis Cushman
Globigerina topilensis Cushman
Globorotalia centralis Cushman and Bermudez
Cibicides sassei Cole
Cibicides westi Howe
Eponides mexicana (Cushman)
Anomalina umbonata Cushman
Discocyclina perpusilla Vaughan
Textularia zapotensis Cole
Cornuspira olygogyra Hantken
Quinqueloculina mauricensis Howe
Nodosaria longicosta d'Orbigny
Dentalina mauricensis Howe and Roberts

Dentalina sp. (3) Howe
Marginulina huneri Howe
Lagena mauricensis Howe and Ellis

The new species of Foraminifera described in the following pages were obtained from samples of two very carefully cored wells in the Urania oil field of Grant and LaSalle parishes, from samples of a completely cored Cane River section of a well in the Georgetown oil field in Grant Parish, from surface samples collected by Justin Rukas during his survey of Natchitoches Parish, and from similar samples collected by Dr. R. Dana Russell and me during the former's survey of Bienville Parish.

A comparison of the Foraminiferal assemblages of the Weches formation of Texas and that of the Enterprise greensand of Mississippi with that of the Cane River formation of Louisiana reveals a close relationship. This, coupled with the fact that the lithology is also quite similar indicates that the Cane River is at least in part equivalent to these formations.

ACKNOWLEDGMENTS

I am happy to express my thanks to Dr. H. V. Howe for the use of samples collected for him, for the use of his type collection, and for his helpful criticism during the preparation of this paper; to Dr. James H. McGuirt, who unselfishly gave much time in consultation; to Dr. R. Dana Russell and to Dr. John Huner for aid in the collecting of samples; to Justin Rukas for the use of samples collected by him and for information given during several conversations; to Dr. H. N. Fisk through whose assistance the key set of well cores was obtained; and to C. M. Bowers and son who furnished the set of cores.

LIST OF LOCALITIES

Samples No. 1–106, C. M. Bowers et al. E. T. Morrison No. 1, 3040′ W. of E. and 2740′ N of S. lines of S. 24, T. 9 N., R. 1 W. Grant Parish, 106 core samples ranging in depth from 1436′ to 1656′.

1	1436′	Sparta-Cane River contact (?) brown-gray, lignitic, silty shale.
2	1446′	gray-brown clayey, silty sand.
3	1541′	brown to black silty sand, may be cuttings.
4	1541′	dark brown-gray shale, beginning of continuous cores.
5	1542′	"
6	1543′	dark chocolate-brown shale.
7	1544′	"
8	1548′	"
9	1549′	dark chocolate-brown silty shale.
10	1552′	"
11	1553′	"
12	1554′	"
13	1555′	"
14	1556′	same but darker in color.
15	1557′	quite a distinct change, light to dark gray silty shale with a good show of greensand.
16	1557½′	chocolate-brown shale, silty.
17	1558′	"
18	1559′	"
19	1560′	"
20	1561′	"
21	1562′	"
22	1564′	"
23	1565′	same but slightly more silty.
24	1566′	distinct break, light to dark gray silty shale with greensand.
25	1567′	same but more silty.
26	1568′	dark gray shale, contains pockets of greensand.
27	1569′	dark gray shale.
28	1570′	dark green-gray shale.
29	1571′	light green-shale shale.
30	1572′	dark gray shale with some greensand.
31	1572½′	"
32	1573′	greensand marl with some shale.
33	1574′	"
34	1575′	same with more greensand, very little shale.
35	1577′	gray-green shale with pockets of greensand.
36	1578′	same with considerable greensand.
37	1579′	"
38	1580′	gray-green shale with pockets of greensand top of *Discocyclina advena* zone.
39	1581′	"
40	1582′	"
41	1583′	"
42	1584′	"
43	1585′	fine-grained light gray-green siltstone with some greensand.
44	1586′	much like above but with more greensand.
45	1587′	"
46	1588′	"
47	1589′	"
48	1590′	"
49	1591′	more sandy, approaching character of "salt and pepper" sand.
50	1591½′	greensand and shale.
51	1592′	"
52	1593′	greensand base of *D. advena* zone.
53	1594′	"
54	1595′	"
55	1596′	light green-gray silstone and shale with some greensand.
56	1597′	"
57	1598′	"
58	1599′	"

59	1600′	light green-gray silstone and shale with some greensand.
60	1601′	"
61	1602′	"
62	1603′	"
63	1603½′	"
64	1604′	"
65	1605′	"
66	1606′	"
67	1606½′	"
68	1607′	"
69	1608′	same with more greensand.
70	1609′	"
71	1610′	"
72	1610½′	"
73	1611′	same, a little more sandy.
74	1612′	definitely more glauconitic.
75	1613′	"
76	1614′	"
77	1614½′	"
78	1615′	"
79	1616′	sand with well developed shale partings.
80	1617′	"
81	1617½′	same but with very little shale.
82	1618′	"salt and pepper" sand with very little shale.
83	1619′	"salt and pepper" sand with shale partings.
84		No lithologic sample.
85	1620′	"salt and pepper" sand.
86	1621′	"
87	1622′	"
88	1623′	same with some shale partings.
89	1624′	"
90	1625′	"salt and pepper" sand with some pyrite and siltstone.
91	1626′	light green-gray siltstone with some pyrite.
92	1627′	siltstone as above but with considerable shale partings and some greensand toward bottom of the sample.
93	1628′	"salt and pepper" sand with shale partings.
94	1629½′	grades from a fine grained "salt and pepper" sand to a siltstone, shale partings present.
95	1631½′	"salt and pepper" sand.
96	1632½′	"
97	1634′	"
98	1635′	same with little shale and considerable quartz sand.
99	1636′	small amount of green shale, predominance of quartz sand.
100	1643′	gray-brown silty shale, lies below 7′ of unfossiliferous quartz sand.
101	1644′	gray-brown silty shale.
102	1645′	same with some glauconite.
103	1653′	gray-brown lignitic shale, quartz sand.
104	1654′	same with some glauconite.
105	1655½′	"
106	1656′	very light gray fine sand.

Samples No. 107–144, La. Oil and Ref. Co., Tremont No. 2, 312′5″ East and 345′ North of the Southwest corner of the S.W. ¼ of Sec. 29, T. 10 N., R. 2 E. LaSalle Parish, 38 core samples ranging in depth from 1468′ to 1555′.

Sample No.		
107	1468′	brown silty shale.
108	1469′	"
109	1470′	"
110	1472′	same with some glauconite.
111	1473′	"
112	1475′	"
113	1476′	"
114	1477′	"
115	1479′	"
116	1480′	same with some lignite.
117	1481′	same with some glauconite.
118	1482′	gray-brown shale and greensand.
119	1483′	chocolate-brown shale and greensand.
120	1484′	same with some lignite.
121	1485′	"
123	1486′	"
124	1487′	"
125	1488′	same with some greensand.
126		No lithologic sample.
127	1489′	"
128	1490′	"
129	1491′	same with some lignite.
130	1492′	gray-brown silty shale.
131	1493′	chocolate-brown silty shale.
132	1494′	"
133	1496′	"
134	1497′	"
135	1498′	dark gray shale.
136	1499′	light gray-brown silty shale, lignitic.
137	1503′–1509′	light gray silty shale and greensand.
138	1510′–1520′	same *Discocyclina advena* zone.
139	1521′–1531′	"
140	1533′–1538′	"
141	1539′–1546′	greensand and shale.
142	1547′–1550′	"
143	1551′–1552′	"
144	1553′–1555′	gray shale.

Samples No. 145–183, La. Oil and Ref. Co., Tremont No. 1, 115′ South and 150′ East of the Northwest corner of the N.W. ¼ of the N.E. ¼ of Sec. 30, T. 10 N., R. 2 E. LaSalle Parish, 39 core samples ranging in depth from 1500′ to 1566′

Sample No.		
145	1500′	chocolate brown shale.
146	1501′	"
147	1503′	gray-brown silty shale, glauconitic.
148	1506′	gray shale, very little glauconite.
149	1507½′	glauconitic shale and sand, *D. advena* zone.
150	1508½′	gray-brown shale containing glauconite.
151	1511′	light gray shale and glauconite.
152	1512′	light gray shale and glauconite.
153	1513′	"

154	1514′	light gray shale and glauconite.
155	1515′	light to dark gray silty shale and greensand.
156	1516½′	"
157	1518′	"
158	1519′	"
159	1522′	mostly glauconite, base of *D. advena* zone.
160	1523′	"
161	1525′	gray silty shale with some greensand.
162	1526′	"
163	1527′	"
164	1528′	brown-gray shale with some greensand.
165	1529′	"
166	1531′	gray silty shale with some greensand.
167	1532′	"
168	1533½′	mostly greensand, "salt and pepper" sand.
169	1534½′	"
170	1536′	"
171	1538′	"salt and pepper" sand and silty shale
172	1539′	"
173	1543′	"
174	1544′	"
175	1545′	"salt and pepper" sand and silty shale.
176	1546′	"
177	1548′	"
178	1549′	green shale and silty shale.
179	1551½′	glauconitic silty shale.
180	1552′	"
181	1553′	"
182	1564′	quartz and glauconitic sand and silt.
183	1564′–1566′	"

Samples No. 184–219, J. M. Rukas' surface localities in Natchitoches Parish, Louisiana.

Sample No.

184 Ru. 531, NE ¼ of sec. 3, Ashland Twp. on road to Strange, La., *D. advena* zone.

185 Ru. 510, SE ¼ SE ¼ NW ¼ of sec. 8, T. 8 N., R. 8. W.

186 Ru. 503, type locality of Cane River formation, ½ mile of Natchitoches, La.

187 Ru. 468, from a hand dug well 42′ deep at Limekiln Church, NW ¼ of sec. 85, T. 9 N., R. 7 W., greensand marl member.

188 Ru. 463, 1.4 miles north of Provencal on Provencal-Hagewood road and .2 mile east of road in creek bed, *D. advena* zone.

189 Ru. 356, 1.2 miles west of cross-roads east

EXPLANATION OF PLATE 25

FIGS. *1, 2—Ammomarginulina decorata* Hussey, n. sp. ×45. Holotype slide no. 2502, sample no. 166 (p. 118)

3—Marginulina anconoides Hussey, n. sp. ×42. Holotype slide no. 2524, sample no. 123. (p. 122)

4—Marginulina darbyella Hussey, n. sp. ×42. Holotype slide no. 2523, sample no. 173. (p. 122)

5—Marginulina striatoglabrata Hussey, n. sp. ×43. Holotype slide no. 2537, sample no. 113. (p. 123)

6—Robulus translucidus Hussey, n. sp. ×43. Holotype slide no. 2543, sample no. 107. (p. 125)

7—Marginulina insignifica Hussey, n. sp. ×42. Holotype slide no. 2525, sample no. 123. (p. 122)

8—Textulariella polygona Hussey, n. sp. ×54. Holotype slide no. 2504, sample no. 151. (p. 119)

9—Marginulina producta Hussey, n. sp. ×43. Holotype slide no. 2528, sample no. 139. (p. 123)

10—Plectina robusta Hussey, n. sp. ×20. Holotype slide no. 2505, sample no. 110. (p. 119)

11—Robulus trochoides Hussey, n. sp. ×16. Holotype slide no. 2541, sample no. 164. (p. 124)

12—Robulus umbonatus Hussey, n. sp. ×16. Holotype slide no. 2542, sample no. 124. (p. 124)

13—Robulus limbatus Hussey, n. sp. ×50. Holotype slide no. 2540, sample no. 165. (p. 124)

14, 15—Quinqueloculina parvatriangularis Hussey, n. sp. ×48. Holotype slide no. 2519, sample no. 109 (p. 121)

16, 21—Quinqueloculina fragilissima Hussey, n. sp. ×48. Holotype slide no. 2520, sample no. 111. (p. 121)

17, 18—Quinqueloculina acuta Hussey, n. sp. ×48. Holotype slide no. 2517, sample no. 118. (p. 120)

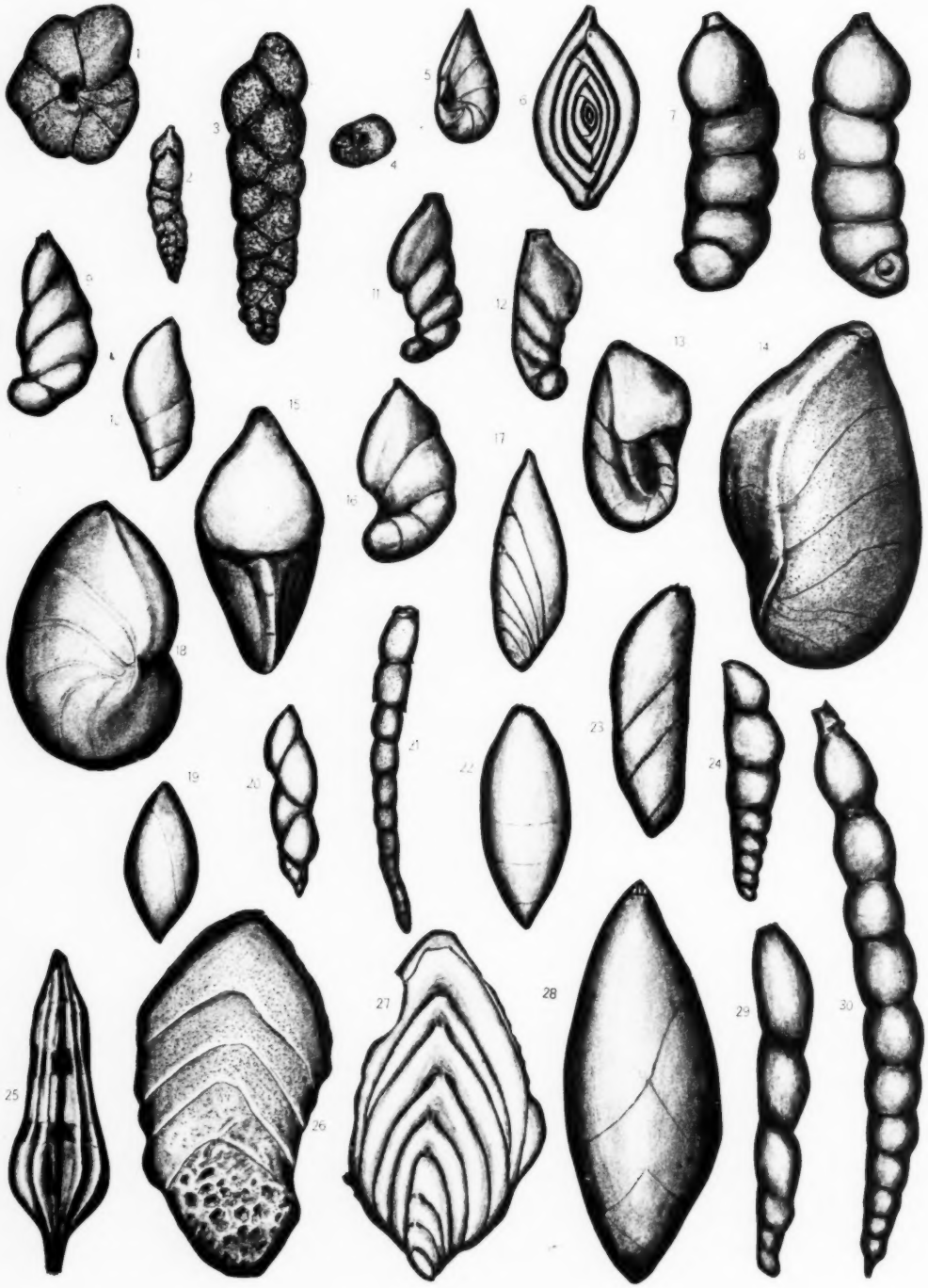
19, 20—Quinqueloculina amygdulata Hussey, n. sp. ×48. Holotype slide no. 2516, sample no. 152. (p. 120)

22, 23—Quinqueloculina striaturata Hussey, n. sp. ×48. Holotype slide no. 2518, sample no. 107. (p. 120)

24, 25—Quinqueloculina gibbosa Hussey, n. sp. ×48. Holotype slide no. 2514, sample no. 107. (p. 120)

26, 27—Quinqueloculina subgibbosa Hussey, n. sp. ×48. Holotype slide no. 2515, sample no. 107. (p. 120)

Hussey, Eocene Foraminifera



Hussey, Eocene Foraminifera

of Victoria Hill, SW ¼ NW ¼ NE ¼ of sec. 24, T. 8 N., R. 9 W., road-cut, top of *D. advena* zone.

190 Ru. 226, about 0.6 miles west of Provencal on north side of tracks of T. & P. RR., NW ¼ SW ¼ SE ¼ of sec. 20, T. 8 M., R. 8 W., *D. advena* zone.

191 Ru. 221, about ¾ mile south-east of Victoria on road south of and parallel to railroad, SW ¼ SE ¼ NW ¼ of sec. 19, R. 8 W., *D. advena* zone.

192–197 Ru. 500B, C. E. H. I.; Clear Lake bluff exposure, NW ¼ of sec. 28, T. 11 N., R. 6 W., includes base of chocolate-brown clay and entire greensand marl member of the Cane River. Is best known exposure of Cane River beds in Louisiana.

198–214 Ru. 518A–Q, NW ¼ NE ¼ NW ¼ of sec. 6, R. 6 W., in center of negro settlement, 40′ hole extending from 12′ above *D. advena* zone to 8′ below it.

215 Ru. 555, SE ¼ SE ¼ of sec. 17, T. 8. N., R. 8. W., bore-hole atop upper Cane River locality, through lower part of chocolate-brown clay into greensand marl.

216 Ru. 524, 200 yards east of Ru. 523 on north side of road, lower part of chocolate-brown clay member.

217 Ru. 523, SW ¼ SW ¼ SW ¼ of sec. 2, T. 13 N., R. 7 W., in lower part of chocolate-brown clay member.

218 Ru. 511, NW ¼ NW ¼ sec. 8, Provencal Twp., *D. advena* zone.

219 Ru. 350, about 2.3 miles south of Hagewood on sideroad about 400 yards west of Louisiana State Highway 39, in SW ¼ of sec. 8, Provencal Twp., *D. advena* zone.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERA
Family AMMODISCIDAE
Genus AMMODISCUS Reuss, 1861
AMMODISCUS INCERTUS (d'Orbigny)

Operculina incertus d'Orbigny, Foram. *In de la Sagra, etc.* Cuba, 1839, p. 71, pl. 6, figs. 16, 17.

EXPLANATION OF PLATE 26

FIG. *1—Haplophragmoides complanata* Hussey, n. sp. ×72. Holotype slide no. 2503, sample no. 128. (p. 118)

2—Listerella minuta Hussey, n. sp. ×72. Holotype slide no. 2513, sample no. 107. (p. 119)

3, 4—Plectina regularis Hussey, n. sp. ×72. Holotype slide no. 2507, sample no. 182. (p. 119)

5—Planularia parva Hussey, n. sp. ×68. Holotype slide no. 2544, sample no. 107. (p. 125)

6—Spiroloculina lamposa Hussey, n. sp. ×72. Holotype slide no. 2512, sample no. 185. (p. 121)

7, 8—Marginulina bulbosa Hussey, n. sp. ×57. Holotype slide no. 2538, sample no. 128. (p. 124)

9—Marginulina noncomforma Hussey, n. sp. ×60. Holotype slide no. 2521, sample no. 151. (p. 122)

10—Marginulina inconspicua Hussey, n. sp. ×60. Holotype slide no. 2527, sample no. 157. (p. 123)

11, 12—Marginulina inornata Hussey, n. sp. ×60. Holotype slide no. 2538, sample no. 185. (p. 123)

13—Saracenaria parva Hussey, n. sp. ×68. Holotype slide no. 2555, sample no. 110. (p. 126)

14—Saracenaria perforata Hussey, n. sp. ×68. Holotype slide no. 2553, sample no. 14. (p. 125)

15, 18—Saracenaria limbata Hussey, n. sp. ×68. Holotype slide no. 2554, sample no. 113. (p. 126)

16—Marginulina subglobosa Hussey, n. sp. ×62. Holotype slide no. 2526, sample no. 157. (p. 123)

17—Astacolus complanatus Hussey, n. sp. ×34. Holotype slide no. 2545, sample no. 162. (p. 125)

19—Guttulina obscura Hussey, n. sp. ×68. Holotype slide no. 2559, sample no. 149. (p. 129)

20—Paleopolymorphina eocaenica Hussey, n. sp. ×68. Holotype slide no. 2558, sample no. 162. (p. 128)

21—Nodosaria delicata Hussey, n. sp. ×66. Holotype slide no. 2548, sample no. 158. (p. 127)

22—Glandulina simplex Hussey, n. sp. ×66. Holotype slide no. 2561, sample no. 158. (p. 130)

23—Dentalina paradoxa Hussey, n. sp. ×66. Holotype slide no. 2550, sample no. 1888. (p. 126)

24—Dentalina globata Hussey, n. sp. ×66. Holotype slide no. 2551, sample no. 115. (p. 126)

25—Nodosaria pyriformis Hussey, n. sp. ×66. Holotype slide no. 2546, sample no. 150. (p. 127)

26—Palmula decorata Hussey, n. sp. ×66. Holotype slide no. 2557, sample no. 156. (p. 127)

27—Frondicularia elegantissima Hussey, n. sp. ×66. Holotype slide no. 2556, sample no. 107. (p. 125)

28—Guttulina magna Hussey, n. sp. ×66. Holotype slide no. 2560, sample no. 149. (p. 129)

29—Dentalina acinacoides Hussey, n. sp. ×66. Holotype slide no. 2552, sample no. 107. (p. 126)

30—Nodosaria selenoides Hussey, n. sp. ×66. Holotype slide no. 2547, sample no. 119. (p. 127)

Ammodiscus incertus Plummer, Univ. Texas Bull. 2644, 1927, p. 63, pl. 13, figs. 1 a–d. Cole, Bull. Am. Paleontology, vol. 14, no. 51, 1927, p. 10. Howe, Louisiana Geol. Surv. Bull. No. 14, 1939, p. 29, pl. 1, fig. 8.

This species has been reported from the Midway by Mrs. Plummer, from the Guaybal formation of Mexico by Cole, and from the Cook Mountain of Louisiana by Howe. It appears to be confined to the upper part of the chocolate-brown clay member of the Cane River formation. The tests are usually distorted, are fairly common but quite small.

Samples 3–5, 9–12, 14.

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES COMPLANATA Hussey, n. sp.

Plate 26, figure 1

Test free, much compressed, planispiral, involute with slight tendency toward becoming evolute; periphery lobate; chambers distinct, about seven in the last formed whorl; sutures distinct, depressed; wall composed of well-sorted arenaceous material, well cemented, smoothly finished; aperture a simple arched slit at base of apertural face of the last formed chamber.

Dimensions of holotype No. 2503 from Sample No. 128, LaSalle Parish, La.: long diameter 0.32 mm.; short diameter 0.30 mm.; thickness 0.08 mm.

This species is found only in that part of the formation characterized by clay with a considerable amount of fine sand.

Samples 3–5, 8–10, 12–14, 16, 17, 19, 20, 109, 120, 123–125, 128, 129, 131, 132, 161.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES MAURICENSIS Howe

This species is confined to the upper part of the Cane River formation. It was described by Howe from the Cook Mountain formation of Louisiana.

Samples 4, 5, 7–12, 15, 107, 108, 110, 113, 118, 182.

Genus AMMOMARGINULINA Wiesner, 1931

AMMOMARGINULINA DECORATA Hussey, n. sp.

Plate 25, figures 1, 2

Test free, compressed, close coiled, planispiral in early part, later chambers added in a linear series; sutures indistinct; wall agglutinated, thick, composed of tests of small Foraminifera, and of fairly well sorted sand grains, the whole well cemented; aperture terminal, ovate, with slight tendency toward development of a neck.

Dimensions of holotype No. 2502 from Sample No. 166, LaSalle Parish, La.: length 0.92 mm.; width 0.40 mm.; thickness 0.19 mm.

This species occurs too rarely to be of stratigraphic value. However, its outstanding characteristics make it easy to identify.

Samples 4, 114, 131, 166.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA SMITHVILLENSIS Cushman and Ellisor

Textularia smithvillensis Cushman and Ellisor, Cont. Cushman Lab. vol. 9, pt. 4, 1933, p. 95, pl. 10, figs. 10 a, b.

The following is the original description:

Test large, broad at the apertural end, tapering nearly to a point at the initial end, compressed, thickest along the median line, periphery subacute; chambers numerous consisting of 8–10 pairs in the adult, somewhat overlapping, very slightly inflated, of uniform shape, increasing very evenly in size as added; sutures slightly depressed, slightly oblique, often with an anterior bend about midway of the chamber; wall coarsely arenaceous, but fairly smoothly finished; aperture in a semi-circular reentrant of the base of the apertural face. Length up to 1.50 mm.; breadth 0.80 mm.; thickness 0.40 mm.

Holotype (Cushman Coll. No. 19243) from Claiborne Eocene, Weches formation, South bank of Colorado River at Smithville, Bastrop Co., Texas.

This species seems to be characteristic of the Weches formation of Texas. It is probably the ancestor of the related species *T. hockleyensis* Cushman and Applin of the Jackson Eocene, and of *T. tumidulum* Cushman of the Lower Oligocene.

This species is not very abundant in the Cane River. The few specimens found were in the upper chocolate-brown clay member of the formation. It is present in the Weches formation.

Dimensions of hypotype No. 2605 from Sample No. 4, Grant Parish, La.: length 1.45 mm.; width 0.61 mm.; thickness 0.50 mm.

Samples 2–4, 14–16, 18, 102, 107, 109–111, 187, 215.

TEXTULARIA ZAPOTENSIS Cole

Textularia mexicana Cole (not Cushman), Bull, Am. Paleontology, vol. 14, no. 51, 1927, p. 11. pl. 5, fig. 5.
Textularia zapotensis Cole, *May 20, 1929*, Corrigenda slip to same publication.
Textularia zapotensis Nuttall, Jour. Paleontology, vol. 4, no. 3, 1930, p. 275. Howe, Louisiana Geol. Survey Bull. no. 14, 1939, p. 32, pl. 1, figs. 1, 2.

This species, reported by Howe from the Cook Mountain formation in Louisiana, is fairly common throughout most of the Cane River formation. Present in Weches and Enterprise.

Samples, 3–5, 7, 8, 10–26, 30, 32–35, 37, 38, 40–47, 55–58, 60–65, 68, 71, 75, 76, 90, 100, 102, 107–111, 113–121, 123–125, 127–134, 137, 139, 144–146, 148–153, 156–158, 160–171, 183–191, 193, 196, 199, 201, 203–205, 207–209, 211, 212, 214, 215, 217, 219.

Family VALVULINIDAE
Genus TEXTULARIELLA Cushman, 1927
TEXTULARIELLA POLYGONA Hussey, n. sp.
Plate 25, figure 8

Test sub-pyramidal, elongate, chamber arrangement in early stages gives polygonal shape to a transverse-section, more adult stages elliptical in transverse-section, early stage triserial, adult biserial; chambers numerous, distinct not inflated; sutures distinct, nearly at right angles to long dimension of the test, slightly depressed; wall of fairly well-sorted, fine arenaceous material, well-cemented; aperture a low slit at the inner margin of last formed chamber.

Dimensions of holotype No. 2504 from Sample No. 151, LaSalle Parish, La.; length 0.52 mm.; greatest diameter 0.31 mm.

Present in the Enterprise formation.

Samples 40, 43, 44, 46, 125, 127, 146, 151, 152, 156–158, 191.

Genus PLECTINA Marsson, 1878
PLECTINA ROBUSTA Hussey, n. sp.
Plate 25, figure 10

Test coiled in the early stages, later with two chambers to a whorl; chambers indistinct, inflated, with chitinous inner lining; wall arenaceous, of fairly well-sorted well-cemented grains; aperture textularian in the early stages, terminal, without neck in adult stage.

Dimensions of holotype No. 2505 from Sample No. 110, length 0.70 mm.; diameter 0.55 mm.

Dimensions of paratype No. 2506 from Sample No. 110, length 1.82 mm.; diameter 0.72 mm., both specimens from LaSalle Parish, La.

The young of this species may be mistaken for young of *Pseudoclavulina elongata*. However, correct identification is easy upon comparison, for even in the young stages the chambers of this species are much more indistinct, than in *P. elongata*.

Samples 14, 15, 19–21, 23, 24, 27, 30, 37, 40, 46, 100, 107, 110–114, 134, 137, 150, 152, 153, 155, 157, 202–205.

PLECTINA REGULARIS Hussey, n. sp.
Plate 26, figures 3, 4

Test elongate, biserial for much the greater part, early stage indistinct but transverse sections prove it to be coiled; chambers distinct, inflated; sutures distinct, depressed; wall arenaceous, of well sorted, well-cemented grains; aperture in early chambers textularian, in adult rounded, terminal with a tendency toward development of a neck.

Dimensions of holotype No. 2507 from Sample No. 182, LaSalle Parish, La.: length 0.70 mm.; greatest width 0.21 mm.; greatest thickness 0.15 mm.

The conspicuous biserial stage and characteristic aperture of this species make it quite easy to identify.

Samples 144, 182.

Genus LISTERELLA Cushman, 1933
LISTERELLA MINUTA Hussey, n. sp.
Plate 26, figure 2

Test elongate, chamber arrangement in early stages indistinct but appears to be coiled, well developed triserial stage gives way to a very short biserial stage which in turn gives way to a uniserial stage in the adult; wall arenaceous, fine grained, well cemented; aperture terminal, with a distinct slender neck.

Dimensions of holotype No. 2513 from Sample No. 107, LaSalle Parish, La.: length 0.34 mm.; width 0.10 mm.

This species though quite small for the genus is very distinctive and was found in a large number of samples from the upper

clay member of the Cane River formation.

Samples 4, 5, 10, 12, 19, 21, 31, 110, 112, 127, 128, 184.

Family MILIOLIDAE
Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA GIBBOSA Hussey, n. sp.
Plate 25, figures 24, 25

Test large for the genus, almost as broad as long, triangular in transverse section with the angles subrounded; chambers distinct; periphery bluntly keeled; sutures very distinct, depressed; wall calcareous, polished, slightly roughened by shallow, longitudinal, elongated grooves; aperture circular with a rather small bifid tooth, no distinct lip.

Dimensions of holotype No. 2514 from Sample No. 107, LaSalle Parish, La.: length 0.85 mm.; greater width 0.64 mm.; lesser width 0.55 mm.

This species is quite like *Quinqueloculina subgibbosa* but is more triangular in transverse section, being nearly as broad as long. Both seem to have about the same range in the Cane River formation.

Samples 4–6, 9–12, 16, 17, 20, 22, 102, 107, 127, 128.

QUINQUELOCULINA SUBGIBBOSA Hussey, n. sp.
Plate 25, figures 26, 27

Test large for the genus, about two-thirds as broad as long, subquadrate in transverse section, chambers distinct; periphery broad, tending toward development of a blunt keel; sutures very distinct; wall polished, only slightly roughened by longitudinal, shallow grooves; aperture circular with a bifid tooth, a well developed neck and lip.

Dimensions of holotype No. 2315 from Sample No. 107, LaSalle Parish, La.: length 0.85 mm.; greater width 0.70 mm.; lesser width 0.45 mm.

This species might be mistaken for *Quinqueloculina gibbosa* but is found to be sufficiently different on comparison. *Q. gibbosa* has only a faint lip and is subtriangular in transverse section whereas *Q. subgibbosa* has a distinct lip and is subquadrate in transverse section.

Samples 3, 8, 9, 13, 14, 17–19, 21, 23, 35, 107, 108, 111, 113, 116, 123–125, 128.

QUINQUELOCULINA AMYGDULATA Hussey, n. sp.
Plate 25, figures 19, 20

Test of medium size for the genus, about two-thirds as broad as long, subtriangular in transverse section, ovate in longitudinal section; chambers distinct, slightly inflated, periphery rounded to bluntly keeled; sutures sharply marked; wall very slightly pitted, not polished, aperture simple, oval, without tooth, neck only slightly developed, no lip.

Dimensions of holotype No. 2516 from Sample No. 152, LaSalle Parish, La.: length 0.48 mm.; greater width 0.30 mm.; lesser width 0.20 mm.

This species occurs most abundantly in the greensand and marl member of the Cane River where its test is almost glassy rather than porcellaneous. Elsewhere in the formation the test is typically porcellaneous. Present in Enterprise formation.

Samples 2, 11–15, 17, 18, 40, 43, 44, 46–49, 53–55, 57, 60, 68, 102, 108, 151, 152, 155, 158, 163, 168, 190, 191.

QUINQUELOCULINA ACUTA Hussey, n. sp.
Plate 25, figures 17, 18

Test elongate, about twice as long as broad, subtriangular in end view, of about medium size for the genus; periphery acute, not keeled; chambers distinct, slightly inflated; sutures very distinct, depressed; wall polished, marked by shallow, longitudinal pits; aperture round, with well developed neck, subdued lip, small, simple tooth.

Dimensions of Holotype No. 2517 from Sample No. 118, LaSalle Parish, La.: length 0.71 mm.; greater width 0.44 mm.; lesser width 0.40 mm.

This is a rather sturdy looking species with a somewhat translucent graceful test. Is found most abundantly in the upper chocolate-brown clay member of the formation. Present in the Weches formation.

Samples 7–14, 16, 17, 20, 22, 27, 30, 31, 55, 56, 102, 107, 109–114, 118, 123–125, 161, 162, 189.

QUINQUELOCULINA STRIATURATA Hussey, n. sp.
Plate 25, figures 22, 23

Test elongate, the type specimen being

about two times as long as broad, other specimens studied were as much as three times as long as broad, ovate in transverse section; periphery broadly rounded; chambers distinct, considerably broader at base than at apertural end; sutures distinct, discontinuous furrows or striae; aperture subtriangular, without tooth, neck produced with only a slight lip.

Dimensions of holotype No. 2518 from Sample No. 107, LaSalle Parish, La.: length 0.83 mm.; greatest width 0.41 mm.; least width 0.30 mm.

This species is the most distinctive *Quinqueloculina* found in the Cane River formation, most common in the lower part of the upper clay member.

Samples 9, 10, 15–27, 30, 33, 34, 100, 102, 103, 105, 107, 110, 111, 116–118, 120, 123–125, 127, 128.

QUINQUELOCULINA PARVATRIANGULARIS
Hussey, n. sp.
Plate 25, figures 14, 15

Test small for the genus, nearly round in side view, triangular, in transverse section, angles sharp; chambers distinct, not inflated, maintaining about the same width from the base to the aperture; sutures distinct, not depressed; periphery almost doubly keeled due to slightly concave outside face of the chambers; wall smooth, semipolished; aperture rounded with simple tooth, no neck or lip.

Dimensions of holotype No. 2519 from Sample No. 109, LaSalle Parish, La.: length 0.27 mm.; greater width 0.22 mm.; lesser width 0.12 mm.

This distinctive species occurs most abundantly in the upper chocolate-brown clay member of the formation. Present in the Weches formation.

Samples 3–6, 8–14, 107, 109, 110, 113, 114, 116, 119, 120, 131.

QUINQUELOCULINA FRAGILISSIMA
Hussey, n. sp.
Plate 25, figures 16, 21

Test nearly as broad as long, of small size, quite fragile, somewhat translucent, periphery acute but not keeled; sutures only fairly distinct, depressed; wall thin, subhyaline, smooth, polished; aperture rounded without a tooth, neck well developed, no lip.

Dimensions of holotype No. 2520 from Sample No. 111, LaSalle Parish, La.: length 0.37 mm.; greater width 0.21 mm.; lesser width 0.15 mm.

The fragile, translucent test of this species makes it comparatively easy to identify.

Present in the Weches formation.

Samples 9, 10, 16–23, 25, 26, 66, 107, 108, 111–113, 115, 116, 119, 120, 123, 125, 128, 149.

QUINQUELOCULINA MAURICENSIS
Howe

Quinqueloculina mauricensis Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 35, pl. 4, figs. 8–10.

This species, described by Howe from the Cook Mountain of Lousiana, occurs but rarely in the Cane River formation, is confined to the upper part of the chocolate-brown clays.

Samples 3, 108, 110, 113.

Genus SPIROLOCULINA d'Orbigny, 1826
SPIROLOCULINA LAMPOSA Hussey, n. sp.
Plate 26, figure 6

Test elliptical in outline, much compressed, slightly biconcave; chambers slightly inflated, added in a single plane, two to a whorl, quinqueloculine stage not discernible; wall calcareous, porcellaneous; aperture terminal, simple, round, without tooth, neck well developed, without lip.

Dimensions of holotype No. 2521 from Sample No. Ru 510-D-185, Natchitoches Parish, La.: length 0.61 mm.; width 0.30 mm.

This species occurs very abundantly in the Cane River. It is very distinctive, and especially characteristic of the greensand marl member of the formation. In peripheral outline it greatly resembles the profile view of an oil lamp of Aladdin's time.

Samples 4, 10, 15–19, 21–25, 27, 30, 32–37, 39–51, 53–65, 67, 70, 74–78, 80, 82, 83, 107, 111–115, 118, 119, 121, 123–125, 127–130, 134–137, 139, 145, 146, 148–152, 155–169, 171, 172, 184–186, 188–190, 192, 193, 197, 205–207, 209–211, 214, 216.

Family OPHTHALMIDIIDAE
Genus CORNUSPIRA Schultze, 1854
CORNUSPIRA OLYGOGYRA Hantken

Cornuspira olygogyra Hantken, Magy. kir, foldt. int. Evkonyve, vol. 4, 1875 (1876), p. 16, pl. 1,

fig. 10. Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 15, pl. 4, fig. 14. Howe, Louisiana Geol. Survey Bull., no. 14, 1939, p. 39, pl. 3, figs. 9, 10.

The characteristic variable appearance of this species as observed by Howe (1939) is duplicated by the many specimens found in the upper part of the Cane River formation in Louisiana. Howe also reports it from the Vicksburg Oligocene in Louisiana, from the Jackson Eocene in Mississippi and from the Cook Mountain Eocene in Louisiana. Present in the Weches formation.

Samples 3, 4, 7, 8, 11–14, 17–24, 26, 30, 102, 107–109, 111, 114, 116, 119–121, 123, 124, 128,-185.

Family LAGENIDAE

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA NONCONFORMA Hussey, n. sp.

Plate 26, figure 9

Test an uncoiling uniserial series of chambers, initial chamber large globular, later chambers increase irregularly in size, few in number, four or five in adult; sutures limbate, slightly depressed; wall calcareous, hyaline, very finely perforate; aperture radiate, quite large for the species, terminal.

Dimensions of holotype No. 2522 from Sample No. 151, LaSalle Parish, La.; length 0.45 mm.; width 0.20 mm.; thickness 0.10 mm.

This species, although distinctive, is not very common, and occurs mostly in the lower part of the greensand marl member of the Cane River formation.

Samples 29–31, 33–37, 63, 79, 103, 105, 112, 115, 124, 127, 146, 174, 175, 184–186, 188, 189, 191, 196, 202–205, 207–211, 213, 217–219.

MARGINULINA ANCONOIDES Hussey, n. sp.

Plate 25, figure 3

Test closely coiled in early portion, planispiral, later portion uncoiled, uniserial; chambers numerous, ten to twelve visible in the adult; periphery bluntly keeled; sutures strongly limbate, glassy, limbate character extends almost to face of specimen; apertural face broad but short, oval-shaped; aperture radiate, without neck.

Dimensions of holotype No. 2524 from Sample No. 123, LaSalle Parish, La.: length 0.88 mm.; width 0.3 mm.; thickness 0.28 mm.

The distinguishing features of this species are the shape of the apertural face and the abrupt angle between the coiled and uncoiled stages. The latter is very noticeable when specimen is viewed from side.

Samples 9, 10, 16–20, 22, 37, 39, 41–44, 55, 61, 62, 65, 71, 74, 124, 127–129, 136, 160, 161, 211, 212.

MARGINULINA DARBYELLA Hussey, n. sp.

Plate 25, figure 4

Test closely coiled and planispiral in early portion, later stages uncoiled uniserial with chambers added in plane to one side of previous plane of coiling; chambers numerous, about nine or ten visible in adult; periphery with well developed thin glassy keel; sutures strongly limbate, raised, glassy, limbate character does not extend all the way to front of specimen; apertural face broad, triangular, aperture radiate, with slight neck.

Dimensions of holotype No. 2523 from Sample No. 173, LaSalle Parish, La.: length 0.81 mm.; width 0.47 mm.; thickness 0.26 mm.

Although these specimens may be varieties of *Marginulina variata*, they are sufficiently abundant to be described as a new species. However, reference to *Marginulina* may be an error, but the specimens are more like *Marginulina* than *Darbyella*.

Samples 16, 22, 30, 35, 36, 42, 44, 54, 55, 68, 70, 74, 102, 108, 110, 114, 115, 124, 127, 129, 186, 187, 191, 197, 205.

MARGINULINA INSIGNIFICA Hussey, n. sp.

Plate 25, figure 7

In very early stages coiled, but uncoiled uniserial, arcuate portion forms greater part of test; chambers slightly compressed, numerous, about twelve or thirteen visible in the adult; periphery bluntly keeled; sutures limbate, glassy, extend to face of specimen; apertural face long and narrow, aperture radiate with a short neck.

Dimensions of holotype No. 2525 from Sample No. 123, LaSalle Parish, La.: length 0.76 mm.; width 0.35 mm.; thickness 0.30 mm.

This species is characterized by its ar-

cuate shape and its very narrow apertural face.

Samples 9, 10, 18–20, 27–29, 128, 167, 201.

MARGINULINA SUBGLOBOSA Hussey, n. sp.
Plate 26, figure 16

Test an uncoiling uniserial series of chambers, initial chamber globular, large, later chambers subglobular, increasing in size, about five or six in the adult; periphery rounded; sutures indistinct, slightly depressed; apertural face broad, concave, aperture radiate, at peripheral angle, no neck.

Dimensions of holotype No. 2526 from Sample No. 157, LaSalle Parish, La.: length 0.46 mm.; width 0.26 mm.; thickness 0.20 mm.

This species is comparatively small for the genus. It differs from *M. nonconforma* in its much broader apertural face.

Samples 15–19, 21, 23, 24, 27–31, 33–35, 38, 40, 42–44, 53, 54, 56–58, 60–62, 65, 68, 70, 71, 116, 119, 127, 130, 135, 136, 141, 144, 151, 152, 175, 190, 199, 202, 203, 206, 210, 213.

MARGINULINA INCONSPICUA Hussey, n. sp.
Plate 26, figure 10

Test of comparatively small size for the genus, very early stage coiled, indistinct, later greater part a uniserial series of chambers; chambers increase in size rapidly, slightly involute, few in number, about five in adult, round in transverse section; sutures distinct, slightly depressed; aperture radiate, at peripheral angle, no neck.

Dimensions of holotype No. 2527 from Sample No. 157, LaSalle Parish, La.; length 0.39 mm.; diameter 1.7 mm.

This species is very close to the common stock of *Dentalina* and *Marginulina*. It is placed in the latter genus on the basis of its very evidently coiled early stage.

Samples 12, 13, 15–20, 22, 27, 29–32, 34–37, 39–41, 54, 55, 124, 125, 128, 130, 133, 137, 140, 145, 146, 148, 151, 158, 161, 163, 164, 166, 171, 175, 184–186, 194, 196, 201, 206, 208, 219.

MARGINULINA PRODUCTA Hussey, n. sp.
Plate 25, figure 9

Test elongate, compressed, coiled in the early stages, later uncoiled, uniserial portion forms much the greater part; chambers numerous, about fourteen visible in the adult; periphery only slightly keeled; sutures limbate, glassy but limbate nature does not persist to the face of specimen; apertural face narrow, nearly horizontal, somewhat recessed, aperture radiate, at peripheral angle.

Dimensions of holotype No. 2528 from Sample No. 139, LaSalle Parish, La.; length 1.38 mm.; width 0.48 mm.; thickness 0.25 mm.

This species is characterized by its large size, the relative length of its uniserial portion and the shape and position of its apertural face.

Samples 9, 15–17, 22, 26–29, 37, 55, 56, 65, 74, 135, 137, 139, 157, 166, 167, 192, 193, 195–197, 201, 210, 212.

MARGULINA STRIATOGLABRATA Hussey, n. sp.
Plate 25, figure 5

Test elongate, early stages indistinct, later stage a uniserial series of chambers, nearly round in transverse section, chambers few, three or more in the adult; sutures broadly depressed, distinct in uniserial portion; wall calcareous, ornamented with numerous longitudinal ridges which extend the length of the early chambers but only half the length of the later chambers, leaving the upper half of each adult chamber smooth; aperture terminal, radiate.

Dimensions of holotype No. 2537 from Sample No. 113, LaSalle Parish, La.: length 0.70 mm.; diameter 0.23 mm.

This species may be confused with *M. huneri* Howe but it can be distinguished by its sutures which are more depressed and by its ridges which are fewer and less persistent.

Present in the Weches formation.

Samples 34, 102, 105, 151–153, 207, 208.

MARGINULINA INORNATA Hussey, n. sp.
Plate 26, figures 11, 12

Test elongate, small for the genus, subtriangular in transverse section, initial chamber globular, others triangular, broadest in front, arranged in uniserial manner; chambers distinct, few in number, slightly inflated; sutures distinct, depressed; wall

calcareous, vitreous, unornamented; aperture radiate, circular, at peripheral angle.

Dimensions of holotype No. 2538 from Sample No. Ru 510-D-185, Natchitoches Parish, La.: length 0.40 mm.; width 0.16 mm.

Samples 5, 7, 53, 151–153, 156–158, 184, 185, 202, 205, 208.

MARGINULINA BULBOSA Hussey, n. sp.
Plate 26, figures 7, 8

Test elongate, early stage coiled, later portion uncoiled in a uniserial manner, slightly arcuate, slightly involute, nearly round in transverse section; chambers distinct, as many as six or seven in the adult; sutures only slightly depressed; wall calcareous, smooth, without ornamentation, individual chambers inflated, bulbous; aperture terminal, radiate.

Dimensions of holotype No. 2539 from Sample No. 128, LaSalle Parish, La.: length 0.70 mm.; diameter 0.24 mm.

The distinguishing features of this species are its total lack of ornamentation, its bulbous chambers, and the fact that the early coiled portion appears to have developed in a plane at right angles to that of the later uniserial uncoiled portion.

Samples 63, 137, 140, 142, 149, 164, 189, 215.

MARGINULINA HUNERI Howe

Marginulina huneri Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 43, pl. 6, figs. 8, 9.

This species, described from the Cook Mountain Eocene by Howe, occurs but rarely in the Cane River formation in Louisiana. Present in the Weches formation.

Sample 152.

Genus ROBULUS Montfort, 1808

ROBULUS LIMBATUS Hussey, n. sp.
Plate 25, figure 13

Test closely coiled with a tendency toward becoming uncoiled at the last chamber, bilaterally symmetrical, involute; chambers numerous, ten or eleven in the last formed volution; periphery bluntly keeled; sutures heavily limbate; wall calcareous, vitreous, quite heavy; aperture radiate, at the peripheral angle, somewhat up-tilted.

Dimensions of holotype No. 2540 from Sample No. 165, LaSalle Parish, La.: short diameter 0.68 mm.; long diameter 0.90 mm.; thickness 0.40 mm.

Samples 41, 46, 55–57, 63–66, 68, 162–167, 194, 214.

ROBULUS TROCHOIDES Hussey, n. sp.
Plate 25, figure 11

Test closely coiled, large for the genus; chambers numerous, twelve or more in the last formed whorl; sutures quite distinct, heavily limbate, raised; periphery slightly carinate; wall calcareous, vitreous, umbilical plug very small; aperture radiate, at the peripheral angle.

Dimensions of holotype No. 2451 from Sample No. 164, LaSalle Parish, La.: diameter 1.25 mm.; thickness 0.70 mm.

This species is characterized by its almost circular outline, the large number of chambers and its distinctive sutures.

Samples 8–10, 16, 19, 22, 24, 40, 42–46, 48, 50–55, 57, 58, 60, 62–65, 137, 139, 151–153, 157–168, 171, 172, 175, 186, 189, 190, 202–204, 212, 213, 215–218.

ROBULUS UMBONATUS Hussey, n. sp.
Plate 25, figure 12

Test closely coiled, bilaterally symmetrical, of large size; chambers moderately numerous, not more than ten or eleven in the last formed volution; sutures limbate, glassy, only slightly raised; periphery with well developed, broadly rounded keel; wall calcareous, smooth, umbilical plug very large, glassy; apertural face of medium height, aperture radiate, an elongated median slit at peripheral angle.

Dimensions of holotype No. 2542 from Sample No. 124, LaSalle Parish, La.: diameter 1.15 mm.; thickness 0.64 mm.

This species may be identified primarily by its very large, glassy umbilical plug; other specific features are its large size and the character of its sutures.

Present in the Weches formation.

Samples 1–5, 7–9, 12–17, 20, 21, 25, 27–29, 32, 34, 35, 38, 40, 41, 43–45, 47, 55, 56, 58, 59, 61–65, 67, 68, 70, 72–74, 107–111, 113–116, 118–121, 123–125, 127, 129–131, 133–135, 145, 146, 148–150, 155, 156, 174, 185–187, 190–193, 195, 197, 199, 201, 202, 204, 205, 207, 209, 210, 211, 212–214, 218.

ROBULUS TRANSLUCIDUS Hussey, n. sp.
Plate 25, figure 6

Test closely coiled, of more than medium size for the genus; chambers triangular in side view, about eight or nine in the last formed volution, very distinct; sutures broad, of clear glassy material, not raised, distinct; wall smooth, vitreous, calcareous, with a large, clear, glassy umbilical plug; apertural face triangular, aperture radiate, an elongated median slit.

Dimensions of holotype No. 2543 from Sample No. 107, LaSalle Parish, La.: diameter 0.70 mm.; width 0.32 mm.

The clear glassy sutures and umbilical plug distinguish this species. The early volutions can be seen through the umbonate center in good specimens.

Samples 10–12, 14, 15, 17–19, 21, 23, 26, 50, 54, 57, 58, 102, 115–118, 120, 123–125, 130, 134, 135, 137, 146, 148, 150, 159, 160, 174, 175, 185, 187, 188, 190, 193, 202, 207, 210, 216.

Genus ASTACOLUS Montfort, 1808
ASTACOLUS COMPLANATUS Hussey, n. sp.
Plate 26, figure 17

Test an uncoiling compressed uniserial series of chambers; chambers comparatively few, only seven visible, very slightly inflated; sutures distinct, slightly depressed; wall calcareous, smooth, glassy, unornamented; aperture terminal, at peripheral angle, radiate.

Dimensions of holotype No. 2545 from Sample No. 162, LaSalle Parish, La.: length 0.88 mm.; width 0.18 mm.

This species closely resembles the early stages of *Frondicularia elegantissima* but it has nearly twice as many chambers and occurs abundantly enough to warrant description as a distinct species.

Samples 61, 62, 65, 128, 156, 158, 162, 211.

Genus FRONDICULARIA Defrance, 1826
FRONDICULARIA ELEGANTISSIMA Hussey, n. sp.
Plate 26, figure 27

Test very thin, fragile, compressed, early chambers triangular in side view, later ones chevron-shaped, extending down both sides but not across base of earlier portion of test, greatest width about midway between initial and apertural ends; chambers distinct, slightly inflated, numerous; sutures distinct, depressed; wall calcareous, smooth translucent; aperture terminal, radiate.

Dimensions of holotype No. 2556 from Sample No. 107, LaSalle Parish, La.: length 0.69 mm.; width 0.47 mm.

Samples 25, 65, 127, 128, 130, 158, 167, 186.

Genus PLANULARIA DeFrance, 1824
PLANULARIA PARVA Hussey, n. sp.
Plate 26, figure 5

Test small, tear-drop shaped, closely coiled with tendency toward becoming uncoiled in the adult stage, compressed; chambers fairly numerous, eight or more in the last formed whorl; sutures distinct, flush with the wall; wall calcareous, vitreous, polished in well preserved specimens, unornamented; aperture at peripheral angle, radiate.

Dimensions of holotype No. 2544 from Sample No. Ru. 226-190, Natchitoches Parish, La.: length 0.39 mm.; width 0.18 mm.

The distinguishing features of this species are its small size and tear-drop shape.

Samples 35, 42, 54, 55, 150–152, 156, 158, 161, 186, 188, 208, 210, 212.

Genus SARACENARIA Defrance, 1824
SARACENARIA PERFORATA Hussey, n. sp.
Plate 26, figure 14

Test triangular in transverse section, broadly concave in front, close coiled in early stages, later becoming uncoiled with chambers arranged in uniserial series; sutures distinct, flush with surface of test; wall calcareous, distinctly perforate; aperture at peripheral angle, radiate, apertural face at angle of sixty degrees or more with long axis of the test.

Dimensions of holotype No. 2553 from Sample No. 148, LaSalle Parish, La.: length 0.73 mm.; width 0.39 mm.

The almost horizontal position of the apertural face and the distinctly perforate wall are the specific features of the species.

Samples 5, 8, 10, 18, 20, 23, 27, 29, 32, 41, 45, 58, 102, 111, 120, 122, 125, 128, 133, 145, 150.

SARACENARIA PARVA Hussey, n. sp.
Plate 26, figure 13

Test small for the genus, early chambers coiled, uncoiled in adult stage, triangular in transverse section; sutures indistinct, flush with wall of test; wall calcareous, smooth; aperture at peripheral angle, radiate, apertural face slightly rounded, nearly at right angles to axis of coiling.

Dimensions of holotype No. 2535 from sample No. 110, LaSalle Parish, La.: length 0.39 mm.; width 0.26 mm.

Superficially this species resembles *S. perforata*, however, it differs in being smaller, not concave in front, not distinctly perforate, and in having a rounded instead of slightly concave apertural face.

Samples 13, 31, 33, 37, 111, 121, 123, 146, 110.

SARACENARIA LIMBATA Hussey, n. sp.
Plate 26, figures 15, 18

Test closely coiled in all but the last one or two chambers, subtriangular in transverse section; sutures limbate, not raised, glassy; wall calcareous, translucent, polished, very finely perforate; aperture at peripheral angle, radiate, apertural face broadly rounded; periphery keeled.

Dimensions of holotype No. 2554 from Sample No. 113, LaSalle Parish, La.: length 0.54 mm.; width 0.39 mm.

The distinctive features of this species are the limbate sutures, polished appearance of the test and the strong rounded keel.

Samples 3, 4, 7–14, 31, 110, 111, 113, 114, 124, 127, 129, 130, 134, 135.

Genus DENTALINA d'Orbigny, 1826
DENTALINA PARADOXA Hussey, n. sp.
Plate 26, figure 23

Test elongate, subfusiform, one side arcuate, the other nearly straight, ovate in transverse section; chambers few, only about four or five in adult; wall calcareous, glassy, unornamented; sutures indistinct, flush with surface of wall, form angle of about 60° with periphery; aperture terminal, radiate.

Dimensions of holotype No. 2550 from Sample No. Ru. 463–188, Natchitoches Parish, La.: length 0.67 mm.; diameter 0.20 mm.

This species lies near the dividing line between the genera *Marginulina* and *Dentalina*. It is referred to *Dentalina* because it has no apparent early coiled stage.

Samples 16, 22, 24, 117, 150, 179, 184, 185, 186, 188.

DENTALINA GLOBATA Hussey, n. sp.
Plate 26, figure 24

Test elongate, subconical; chambers globose, fairly numerous, seven or more in the adult, distinct; sutures distinct, broadly depressed, form greater angle with periphery in adult stage (nearly 90°) than in the early stage; wall calcareous, glassy, translucent, unornamented; aperture terminal, radiate.

Dimensions of holotype No. 2551 from Sample No. 115, LaSalle Parish, La.: length 0.54 mm.; greatest diameter 0.13 mm.

This species is easily identified by its globose chambers and subconical test.

Present in the Weches formation.

Samples 5, 9, 10, 17–19, 22, 34, 41, 42, 44, 114, 115, 119–121, 124.

DENTALINA ACINACOIDES Hussey, n. sp.
Plate 26, figure 29

Test elongate, roughly saber-shaped; chambers about six or more in the adult, increase rapidly in length but slowly in width toward adult portion; sutures very distinct, broadly depressed, maintain about the same angle with the periphery throughout; wall calcareous, translucent; aperture terminal, radiate, at peripheral angle.

Dimension of holotype No. 2552 from Sample No. 107, LaSalle Parish, La.: length 0.78 mm.; greatest width 0.12 mm.

This species can be recognized by the peculiar shape of the individual chambers and by the shape of the test as a whole.

Samples 8, 9, 11, 17, 18, 20, 21, 26, 27, 31, 41, 45, 47, 55, 56, 108, 110, 127–130, 132, 133, 137, 146, 150, 158, 164, 184, 185, 188–190, 196, 202–205, 208, 211, 216.

DENTALINA WINNIANA Howe

Dentalina winniana Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 45, pl. 5, fig. 9.

This species from the Cook Mountain formation of Louisiana, is one of the most common species found in the upper one-third of the Cane River formation.

Samples 4, 5, 7–16, 18, 20, 23–25, 27, 29, 32, 34, 35, 37, 46, 58, 61, 76, 102, 107–116,

118–120, 123–125, 127–131, 133–137, 145, 146, 148, 149, 162–165, 184–191, 202–205, 207–210, 212–214, 219.

Genus NODOSARIA LAMARCK, 1812

NODOSARIA PYRIFORMIS Hussey, n. sp.

Plate 26, figure 25

Test elongate, subpyriform in outline; chambers globose, few in number, only three or four in adult; sutures distinct, wide, broadly depressed, at right angle to axis of test; wall calcareous, translucent, ornamented by eight continuous, strong, longitudinal ridges which extend from the spike-like spine at the base of the test to the terminal, radiate aperture.

Dimensions of holotype No. 2546 from Sample No. 150, LaSalle Parish, La.: length 0.70 mm.; average diameter 0.13 mm.

This species is characterized by its subpyriform shape and by the small number of chambers in the adult test.

Samples 31, 33, 51, 52, 56–58, 151, 164, 175, 196, 212.

NODOSARIA SELENOIDES Hussey, n. sp.

Plate 26, figure 30

Test elongate, arcuate, spike-like spine on initial end; chambers subglobular, numerous, as many as eleven or more in the adult, increase in size uniformly; sutures flush in early stages, later become broadly depressed; wall calcareous, translucent, unornamented; aperture large for the genus, round with well developed neck.

Dimensions of holotype No. 2547 from Sample No. 119, LaSalle Parish, La.: length 1.54 mm.; average diameter 0.16 mm.

This species is easy to identify by its fairly large size, numerous chambers and general shape.

Samples 3, 11, 19–24, 26, 31, 42, 55, 57, 58, 60, 65, 79, 100, 110, 119–121, 123, 124, 128, 139, 145, 151, 160, 161, 163–166, 184, 186, 194, 195, 207, 212, 213.

NODOSARIA DELICATA Hussey, n. sp.

Plate 26, figure 21

Test elongate, arcuate, quite fragile; chambers numerous, as many as twelve or more in the adult, increase in size uniformly, rather barrel-shaped; sutures become increasingly depressed toward adult stage, distinct; wall calcareous, translucent, only ornamentation a tendency toward development of spines at base of each chamber, especially in adult stages; aperture terminal small, radiate, at peripheral angle.

Dimensions of holotype No. 2548 from Sample No. 158, LaSalle Parish, La.; length 0.75 mm.; diameter 0.09 mm.

This species is fairly abundant in the greensand marl member of the Cane River formation but it is so fragile that few complete specimens are found.

Samples 3, 7, 8, 10, 16, 19, 21–24, 26–28, 30, 31, 33, 34, 37–44, 46–50, 61, 62, 65–67, 69–71, 111, 115, 120, 121, 123, 124, 128, 152, 153, 156, 158, 190, 207, 213.

NODOSARIA LONGICOSTA d'Orbigny

Nodosaria longicosta d'Orbigny, Foram. Foss. Bassin Tert. Vienne, 1826, p. 32, pl. 1, figs. 10–12. Plummer, Univ. Texas Bull. 2644, 1926, p. 82, pl. IV, figs. 17 a, b. Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, 1932, p. 35, pl. 7, fig. 8. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 47, pl. 5, fig. 10.

This species is more or less abundantly present throughout the Cane River formation. This occurrence adds support to the belief that it ranges throughout the Tertiary of the Gulf Coast.

Samples 3–5, 7, 9–17, 19–23, 26–33, 35–37, 52, 54–58, 60, 64, 74, 76, 78, 80, 81, 83, 85–87, 102, 107–110, 113–115, 119, 120, 123, 125, 128–132, 145, 179, 184, 186, 187, 190, 193–196, 201, 202, 205, 207, 208, 214, 216.

NODOSARIA VERTEBRALIS (Batsch)

Nautilus vertebralis Batsch, Conch. Seesands, 1791, pl. 2, figs. 6 a–b. (Recent)

Nodosaria vertebralis Brady, Rep. Voy. Challenger, Zool. vol. 9, 1884, p. 514, pl. 63, fig. 35; pl. 64, figs. 11–14. Cushman, U. S. Geol. Survey Prof. Pap. 133, 1923, p. 27, pl. 4, fig. 1. Plummer, Univ. Texas Bull. 2644, 1926 (1927), p. 88, pl. 5, fig. 10. (Eocene)

Nodosaria obliqua Cushman, U. S. Geol. Survey Prof. Pap. 129F, 1921, p. 129, pl. 30, fig. 6. (Eocene to Recent)

Nodosaria vertebralis Galloway and Morrey, Bull. Am. Paleontology, vol. 15, no. 55, 1930, p. 14, pl. 1, figs. 10 a, b.

This distinctive species is fairly common throughout the Cane River formation of Louisiana. Complete specimens are rare.

Samples 16, 18, 20–25, 27–30, 32–37, 39–42, 44, 45, 47, 55–57, 59, 61–65, 76–78, 83, 91, 94, 100, 146, 148–151, 153, 156–160, 163–167, 169, 170, 172, 173, 186, 201, 203, 212.

Genus LAGENA Walker and Jacob, 1798
LAGENA FENESTRISSIMA Howe and Ellis

Lagena fenestrissima Howe and Ellis, Louisiana Geol. Survey Bull. No. 14, 1939, p. 50, pl. 6, fig. 18.

This species, described by Howe and Ellis from the Cook Mountain formation of Louisiana, also occurs in the upper half of the Cane River formation, and in the Weches and Enterprise.

Samples 9, 11, 16, 18–20, 24–30, 32, 34, 37, 39–43, 47, 51, 54, 55, 107, 110, 114–116, 120, 122–125, 127–130, 137, 145, 146, 148–150, 157–159, 161, 164, 171, 173, 175, 179–181, 184, 185, 187–189, 191–197, 203, 204, 206, 208–210, 212, 215, 218, 219.

LAGENA MAURICENSIS Howe and Ellis

Lagena mauricensis Howe and Ellis, Louisiana Geol. Survey Bull. No. 14, 1939, p. 51, pl. 6, fig. 13.

The Cane River specimens appear to be identical to the species described from the Cook Mountain Eocene.

Samples 4, 31, 37, 55, 63, 65, 107, 110, 111, 120, 127, 128, 137, 151, 156–158, 166, 172, 174, 187, 197, 208.

LAGENA OUACHITAENSIS Howe and Wallace

Lagena ouachitaensis Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 1, 1932, p. 29, pl. 6, fig. 19. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 51, pl. 6, fig. 17.

This species has been reported from the Jackson and Cook Mountain formations. It occurs infrequently in the Cane River Eocene of Louisiana.

Samples 34, 53, 115, 116, 123, 124, 137, 155–157, 168, 173, 113.

LAGENA STRIATA (d'Orbigny) var. STRUMOSA Reuss

Lagena strumosa Reuss, Zeitschr. geol. Ges., 1858, p. 434; Sitz. Akad. Wiss. Wien., vol. 46 pt. 1, 1862, p. 328, pl. 4, fig. 49.
Lagena striata (d'Orbigny) var. *strumosa* Cushman, Contrib. Cushman Lab. Foram. Res., vol. 5, pt. 3, 1929, p. 70, pl. 11, figs. 7, 8. Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, 1932, p. 30, pl. 6, fig. 11. Howe, Lousiana Geol. Survey Bull. No. 14, 1939, p. 52, pl. 6, fig. 19.

There is no essential difference between the specimens in the Cane River samples and those from Jackson and Cook Mountain Eocene.

Samples 1, 133, 112.

Genus PALMULA Isaac Lea, 1833
PALMULA DECORATA Hussey, n. sp.
Plate 26, figure 26

Test elongate, early portion closely coiled, later portion uncoiled, uniserial; chambers indistinct in coiled portion, very distinct in uniserial portion; sutures distinct only between chambers in the uniserial portion of the test, limbate, raised; wall calcareous, reticulate in the early coiled portion, coarsely perforate in adult portion; aperture terminal, elongate, internally fluted, with a slightly developed lip.

Dimensions of holotype No. 2557 from Sample No. 156, LaSalle Parish, La.: length 0.80 mm.; width 0.49 mm.

This species is very distinctive but not abundant enough to be of importance as an index fossil. It somewhat resembles *Coleites reticulosus* (Plummer) from the Wilcox of Alabama and the Midway of Texas, and also *Palmula huneri* Howe from the Cook Mountain of Louisiana. It may be wrongly referred to the Lagenidae, as the young forms resemble some species of the *Siphonina*, except for the aperture which is internally quite irregularly notched or fluted.

Samples 26, 43–45, 58, 65, 66, 156, 164, 167, 172.

Family POLYMORPHINIDAE
Genus PALEOPOLYMORPHINA Cushman and OZAWA, 1930
PALEOPOLYMORPHINA EOCAENICA Hussey, n. sp.
Plate 26, figure 20

Test elongate, coiled in very early stage, later becoming biserial; chambers few in adult stage, only four or five, inflated; sutures distinct, depressed; wall calcareous, hyaline; aperture terminal, simple, round.

Dimensions of holotype No. 2558 from Sample No. 162, LaSalle Parish, La.: length 0.42 mm.; diameter 0.09 mm.

This species is characterized by the very small size of the early chambers. It occurs with fair abundance in the lower and middle part of the Cane River formation, thus extending the range of this genus from the Upper Cretaceous well up into the Eocene.

Samples 40, 42–45, 47, 54, 55, 57, 59–67, 71–74, 111, 139, 141, 150–152, 156, 158, 159, 161–167, 173, 186, 190, 194–197, 209, 211, 213.

Genus GUTTULINA d'Orbigny, 1839

GUTTULINA OBSCURA Hussey, n. sp.

Plate 26, figure 19

Test small for the genus, biconical in outline; chambers few, increasing rapidly in size as added, early ones obscure; sutures indistinct, flush with surface; wall smooth, very finely perforate, glassy; aperture terminal, radiate.

Dimensions of holotype No. 2559 from Sample No. 149, LaSalle Parish, La.: length 0.36 mm.; width 0.18 mm.

The small size and the shape of this species are its most distinguishing features.

Samples 5, 10, 14, 21, 42, 48, 53–55, 66, 68, 101, 108, 109, 111, 115, 160, 167, 187, 191, 203, 208, 218.

GUTTULINA MAGNA Hussey, n. sp.

Plate 26, figure 28

Test definitely fusiform, of medium size; chambers increase rapidly in size as added, fairly numerous, only those in the more adult stage being distinct; sutures indistinct, flush with surface; wall calcareous, hyaline; aperture terminal, radiate.

Dimensions of holotype No. 2560 from Sample No. 158, LaSalle Parish, La.: length 0.89 mm.; greatest diameter 0.36 mm.

This species may be identified by its definite fusiform shape and by its fairly large size.

Samples 40, 43, 44, 48, 49, 53, 61, 68, 114, 152, 153, 156, 158, 162, 187, 209, 213.

GUTTULINA IRREGULARIS (d'Orbigny)

Globulina irregularis d'Orbigny, Foraminifères fossiles du bassin Tertiare de Vienne, 1846, p. 226, p. 13, figs. 9, 10.

Guttulina irregularis Cushman and Thomas, Jour. Paleontology, vol. 3, 1929, p. 177, pl. 23, figs. 2 a–c. Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, art. 6, 1932, p. 25, pl. 3, figs. 4, 5; pl. 7, figs. 1, 2, Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 52, pl. 6, fig. 20.

This is a common species throughout most of the marine formations in the Gulf Coast Tertiary section from early Eocene to at least middle Miocene.

It also occurs in the Enterprise formation.

Samples 1, 4, 5, 8, 9, 12, 16, 18, 19, 22, 25, 27, 29, 31, 33–35, 37, 41, 42, 47–50, 54, 55, 109, 120, 137, 149–152, 155, 156, 158, 161, 163, 167, 173, 185, 203, 210.

GUTTULINA AUSTRIACA d'Orbigny

Guttulina austriaca d'Orbigny, Foraminifères fossiles du bassin Tertiare de Vienne, 1846, p. 223, pl. 12, figs. 23–25. Howe and Wallace, Louisiana Dept. Cons. Geol. Bull. 2, 1932, p. 47, p. 8, fig. 3. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 52, pl. 6, figs. 21, 22.

This species is found in most of the Gulf Coast Tertiary marine formations including the Weches.

Samples 4, 5, 7, 8, 10–14, 16, 19, 25, 27, 29, 32, 34, 37–42, 50, 54–56, 64, 65, 83, 84, 100, 107, 108, 110, 113–115, 117, 119, 120, 124, 128, 129, 133, 134, 148, 149, 151, 152, 154, 155, 157, 159–161, 163, 172, 179, 180, 186–189, 193, 196, 201, 204, 205, 209–213, 218, 219.

Genus GLOBULINA d'Orbigny, 1839

GLOBULINA GIBBA d'Orbigny

Globulina gibba d'Orbigny, Ann. Sci. Nat., vol. 7, 1828, p. 226, No. 10, Modeles No. 63. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 53, pl. 6, figs. 25, 26, (For other references to this species see: Cushman, U. S. Nat. Mus. Proc., vol. 77, art. 6, 1930, p. 60.)

This species is quite common through the Tertiary of the Gulf Coast. It occurs in the Weches and Enterprise formations.

Samples 1, 3–5, 7–10, 12–14, 16–23, 25–37, 41, 42, 53–58, 60, 63–65, 71, 83, 84, 86, 102, 107–110, 112–116, 118, 119, 121, 123, 124, 127–129, 133–135, 137, 145, 149, 161, 179–181, 185–191, 193, 196, 201, 204, 205, 208–213, 217–219.

Genus SIGMOIDELLA Cushman and Ozawa, 1928

SIGMOIDELLA PLUMMERAE Cushman and Ozawa

Sigmoidella plummerae Cushman and Ozawa U. S. Nat. Mus. Proc., vol. 77, art. 6, 1930, p. 142, pl. 39, figs. 3 a, b. Howe, Louisiana Geol Survey Bull. No. 14, 1939, p. 56, pl. 7, fig. 14.

This species, described from the Weches of Texas and reported as present in the Cook Mountain of Louisiana, is fairly common in the Cane River of Louisiana.

Samples 8–14, 16, 18–23, 25, 27–34, 37, 39–43, 61–64, 71, 87, 102, 107–111, 113–115,

117–121, 123–125, 127–130, 132–137, 139, 143, 145, 146, 148, 149, 157, 159, 161–163, 165–166, 168, 174, 177–181, 186–189, 191–196, 201, 202, 204, 205, 209–213, 215, 216, 218.

Genus GLANDULINA d'Orbigny, 1826
GLANDULINA SIMPLEX Hussey, n. sp.
Plate 26, figure 22

Test subfusiform in outline, very early chambers biserial, later ones uniserial; chambers rapidly increase in size as added; sutures slightly depressed, rather indistinct; wall smooth, hyaline, finely perforate; aperture terminal, radiate.

Dimensions of holotype No. 2561 from Sample No. 158, LaSalle Parish, La.: length 0.52 mm.; greatest diameter 0.22 mm.

This is a typical *Glandulina* but the biserial stage is very small. It might easily be mistaken for a *Pseudoglandulina*. It occurs in the Enterprise formation.

Samples 3, 5, 7, 9–11, 13, 31, 102, 109–111, 137, 151, 156, 158, 176, 179, 185, 189, 203, 204, 210, 211.

Family NONIONIDAE
Genus NONION Montfort, 1808
NONION MICRUM Cole

Nonion micrus Cole, Bull. Am. Paleontology, vol. 14, no. 51, 1927, p. 22, pl. 5, fig. 12. Weinzierl and Applin, Jour. Paleontology, vol. 3, 1929, p. 400, pl. 43, figs. 6 a–c.
Nonion micrum Cushman, U. S. Geol. Survey Prof. Paper 181, 1935, p. 30, pl. 11, figs. 14, 15. Howe, Louisiana Geol. Survey Bull. No. 14, p. 58, 1929, pl. 7, figs. 22, 23.

This species occurs with more or less abundance at least from the Claiborne to the Jackson. It is present in the Weches.

Samples 4, 5, 8, 10, 16, 18–25, 27–44, 47, 50–56, 59–61, 63–65, 71, 75, 76, 78–80, 82, 83, 107–111, 113–116, 118–121, 123–125, 127–130, 132, 134, 135, 137, 143, 145, 146, 148–150, 152, 156, 180, 181, 185, 191–193, 195–197, 199, 202, 205, 206, 208, 209, 212, 214, 216, 217.

NONION PLANATUM Cushman and Thomas

Nonion planatum Cushman and Thomas, Jour. Paleontology, vol. 4, 1930, p. 37, pl. 3, figs. 5 a, b. Howe, Louisiana Survey Bull. No. 14, 1939, p. 58, pl. 7, figs. 24, 25.

This is a fairly common species throughout the lower Tertiary marine formations of the Gulf Coast, including the Enterprise.

Samples 4, 5, 7, 8, 12–14, 18, 19, 21, 23, 25, 26, 30–35, 39–42, 60, 64, 75, 76, 78, 79, 84, 86, 87, 92, 94, 95, 109, 110, 115, 116, 118, 119, 123–125, 127–132, 143–146, 148–151, 164, 180, 187, 189–191, 193, 195, 196, 199, 201–208, 210–212, 214, 218, 219.

Genus NONIONELLA Cushman, 1926
NONIONELLA WINNIANA Howe

Nonionella winniana Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 60, pl. 7, figs. 26, 27.

This species, described from the Cook Mountain formation of Louisiana, is not uncommon in the greensand marl member of the Cane River formation.

Samples 42–44, 47–49, 53, 90, 155, 157, 158, 180, 181, 186, 188, 190, 191, 208, 209, 211–213, 218, 219.

NONIONELLA MAURICENSIS Howe

Nonionella mauricensis Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 59, pl. 7, figs. 19–21.

This species appears to be identical to the one described from the Cook Mountain formation. It is present in the Enterprise formation.

Samples 31, 32, 41, 43, 63, 64, 120, 123, 127, 130, 137, 143–146, 152, 155, 156, 166, 179, 184–186, 194, 201–203, 205, 207, 208, 210–214, 216.

Family HETEROHELICIDAE
Genus GÜMBELINA Egger, 1899
GÜMBELINA MULTICELLARIS Hussey, n. sp.
Plate 27, figure 10

Test nearly twice as long as broad; chambers numerous, average number eighteen, arranged biserially, increasing gradually in size about half way and thereafter rapidly increasing, globose, inflated; sutures distinct, depressed; wall calcareous, hyaline, unornamented; aperture a large arched opening at base of last formed chamber.

Dimensions of holotype No. 2562 from Sample No. 137, LaSalle Parish, La.: length 0.25 mm.; greatest width 0.12 mm.

This species may be identified by its elongate shape and the comparatively large number of chambers in the adult which suddenly increase in size about half way in the development of the test.

It is present in the Enterprise formation.

Samples 4, 5, 7–9, 18, 19, 24, 108, 109, 113, 124, 125, 128, 130, 132, 211.

Genus GÜMBELITRIA Cushman, 1933

GÜMBELITRIA COLUMBIANA Howe

Gümbelitria columbiana Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 62, pl. 8, fig. 12, 13.

This fairly common species ranges throughout the upper part of the Cane River formation.

Samples 4, 7, 10–12, 14–17, 19, 22, 23, 25, 32, 33, 38, 43, 44, 53, 55, 56, 58, 59, 61, 63, 108–110, 112–115, 117, 119, 120, 122, 124, 125, 127–129, 134, 135, 144, 146–148, 155, 157, 184, 185, 187, 188, 190–192, 194, 197, 199–201, 204, 212, 216.

Family BULIMINIDAE

Genus ROBERTINA d'Orbigny, 1846

ROBERTINA HOWEI Hussey, n. sp.

Plate 27, figures 6, 7

Test an elongate biserial close spiral, spiral suture distinct, other sutures less so; chambers numerous, several in each whorl, slightly inflated; wall calcareous, hyaline to subporcellaneous, polished; aperture an elongate loop, large for the genus.

Dimensions of holotype No. 2564 from Sample No. Ru. 510-D-185, Natchitoches Parish, La.: length 0.29 mm.; diameter 0.11 mm.

This species is named in honor of Dr. H. V. Howe, Director of School of Geology, Louisiana State University.

It is present in the Weches formation.

Samples 12, 21–24, 27–38, 41–45, 111, 120, 121, 124–126, 128–130, 132, 134–137, 146, 149, 150, 184, 190, 199, 201, 202, 204, 205, 208, 209, 216.

Genus BULIMINA d'Orbigny, 1826

BULIMINA ROTUNDA Hussey, n. sp.

Plate 27, figure 24

Test subovate, nearly as broad as long, circular in end view; chambers numerous, inflated; sutures distinct, depressed; wall calcareous, hyaline, distinctly perforate; aperture a loop-shaped opening about half concealed by a thin plate extending from one side of the chamber, nearly terminal.

Dimensions of holotype No. 2565 from Sample No. 137, LaSalle Parish, La.: length 0.46 mm.; diameter 0.31 mm.

This species resembles *Bulimina ovata* d'Orbigny, but differs in being less elongate and more distinctly perforate, and by the character of its aperture. It is present in the Weches formation.

Samples 18, 22, 25, 31, 33, 35–37, 40, 41, 43–50, 53–55, 60, 63, 115, 121, 124, 128, 129, 137, 143, 145, 148, 149, 151, 152, 155–158, 161–170, 179, 180, 184–186, 188–191, 193–195, 197, 202, 205–211, 214, 216.

BULIMINA ROBERTSI Howe and Ellis

Bulimina robertsi Howe and Ellis, Louisiana Geol. Survey Bull. No. 14, 1939, p. 63, pl. 8, figs. 32, 33.

This little species, described from the Cook Mountain and reported as being abundant there, is also common in all but the lower greensand member of the Cane River Eocene.

Samples 3–5, 7–10, 15–20, 24, 25, 27–33, 35–39, 41, 43, 44, 47, 48, 50–53, 55–61, 63–65, 68, 71, 79, 100, 102, 108–110, 115, 116, 118, 124, 125, 127–137, 139, 144, 146, 148, 149, 152, 156, 158–161, 163, 164, 166–168, 172, 184, 186, 192, 194, 195, 197, 199–201, 203, 205, 206, 210–213, 219.

Genus UVIGERINELLA Cushman, 1926

UVIGERINELLA SUBQUADRATA Hussey, n. sp.

Plate 27, figure 12

Test elongate, in adult stage subquadrate in transverse section, more nearly circular in early portion; chambers in early portion arranged triserially, biserially in adult stage; sutures distinct, irregular, very slightly depressed; wall calcareous, hyaline, distinctly perforate; aperture ovate, with a well developed neck and phialine lip.

Dimensions of holotype No. 2571 from Sample No. 118, LaSalle Parish, La.: length 0.45 mm.; diameter 0.13 mm.

This species may be identified by its subquadrate shape, distinctly perforate wall and definite biserial adult stage.

Samples 8–11, 15–22, 29–31, 33, 37, 40, 42, 50, 51, 59, 61–64, 66–68, 70–73, 79, 80, 84, 86, 87, 110–112, 114, 115, 118–120, 123, 124, 127, 128, 132, 134, 135, 137, 141, 142, 145. 149. 150, 163–169, 179, 180, 188–190, 192–194, 201–203, 206, 211, 212, 219.

Genus UVIGERINA d'Orbigny, 1826
UVIGERINA SUBFUSIFORMIS
Hussey, n. sp.
Plate 27, figure 1

Test elongate, subfusiform; chambers in early portion triserial with tendency toward becoming biserial in adult stage, early chambers small, slightly inflated, later ones fairly large, definitely inflated; sutures distinct, depressed, especially so in adult stage; wall calcareous, ornamented in early portion with discontinuous short costae, adult chambers covered with spines; aperture round, terminal, with short neck and phialine lip.

Dimensions of holotype No. 2572 from Sample No. 107, LaSalle Parish, La.: length 0.40 mm.; greatest diameter 0.19 mm.

This species may have given rise to *Siphogenerina spinulosa* which is very similar in its earlier stages.

Samples 9, 10, 13, 15–19, 21, 25–30, 34–37, 40–44, 46–52, 65, 74, 79, 100, 107, 110, 111, 114–116, 118, 121, 125, 127, 128, 130, 134, 136, 137, 139, 146, 148–150, 159, 160, 166, 167, 171, 186, 189–192, 194, 196, 202, 208, 211, 213.

UVIGERINA BLANCA-COSTATA Cole

Uvigerina blanca-costata Cole, Bull. Am. Paleontology, vol. 14, no. 51, 1927, p. 26, pl. 2, fig. 14. Cushman, Contrib. Cushman Lab. Foram. Res., vol. 13, pt. 3, 1937, p. 74, pl. 11, figs. 3, 4. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 70, pl. 8, figs. 16, 17.

Although the Cane River specimens show considerable variation in size and surface ornamentation, they appear to be referable to this Cook Mountain Eocene species. It is present in the Weches formation.

Samples 2, 3, 7, 9, 13, 14, 28, 29, 33, 37, 38, 40, 79, 149, 159, 185, 199–202.

Genus SIPHOGENERINA Schlumberger, 1883
SIPHOGENERINA SPINULOSA Hussey, n. sp.
Plate 27, figure 13

Test elongate, triserial in early stage, greater part biserial, last one or more chambers uniserial; chambers in very early stage indistinct, later chambers distinct, globular; sutures indistinct in early stage, later very distinct, depressed; wall calcareous, decorated in very early portion with short, discontinuous costae, greater part of test covered with short spines; aperture terminal,

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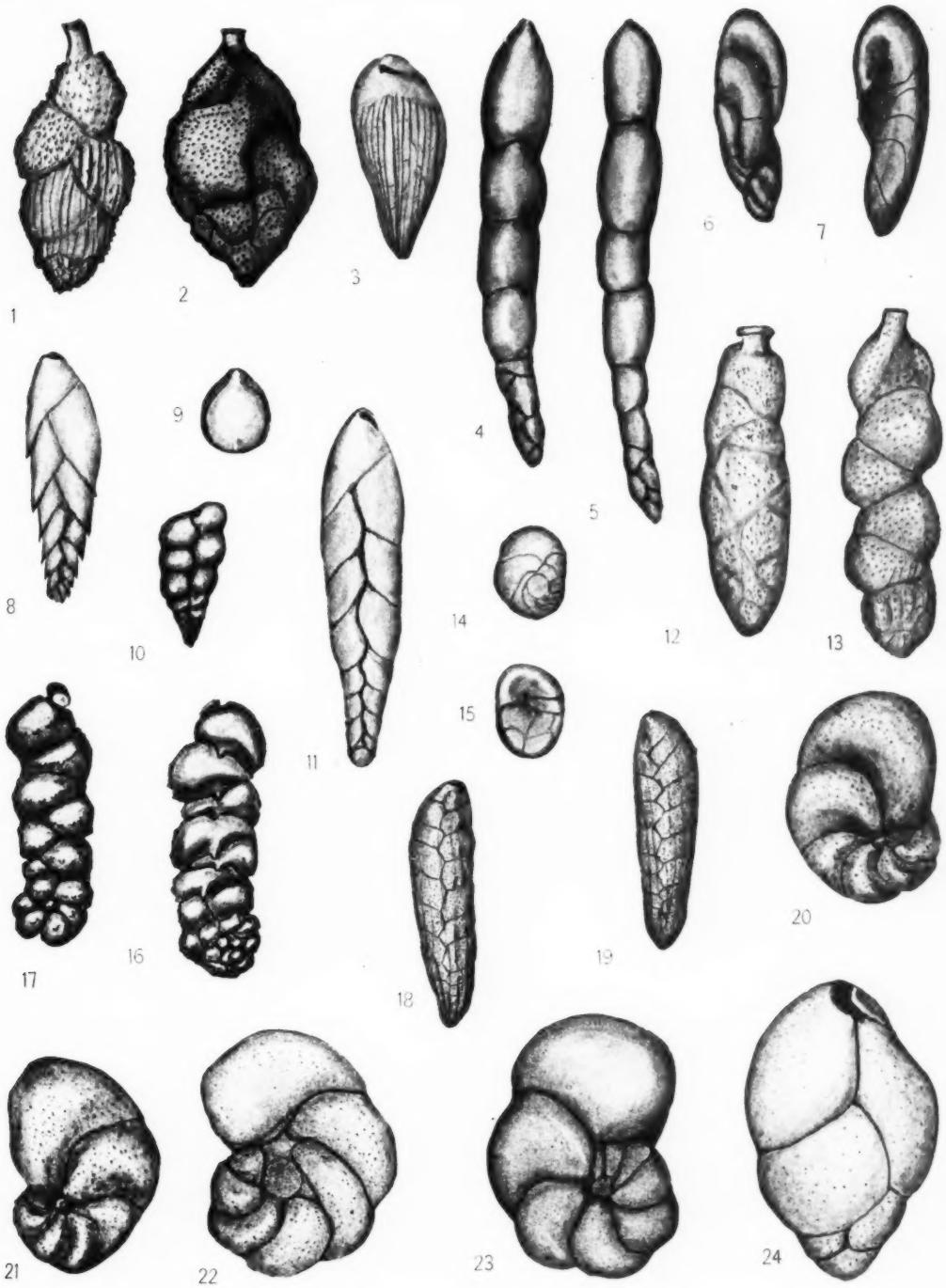
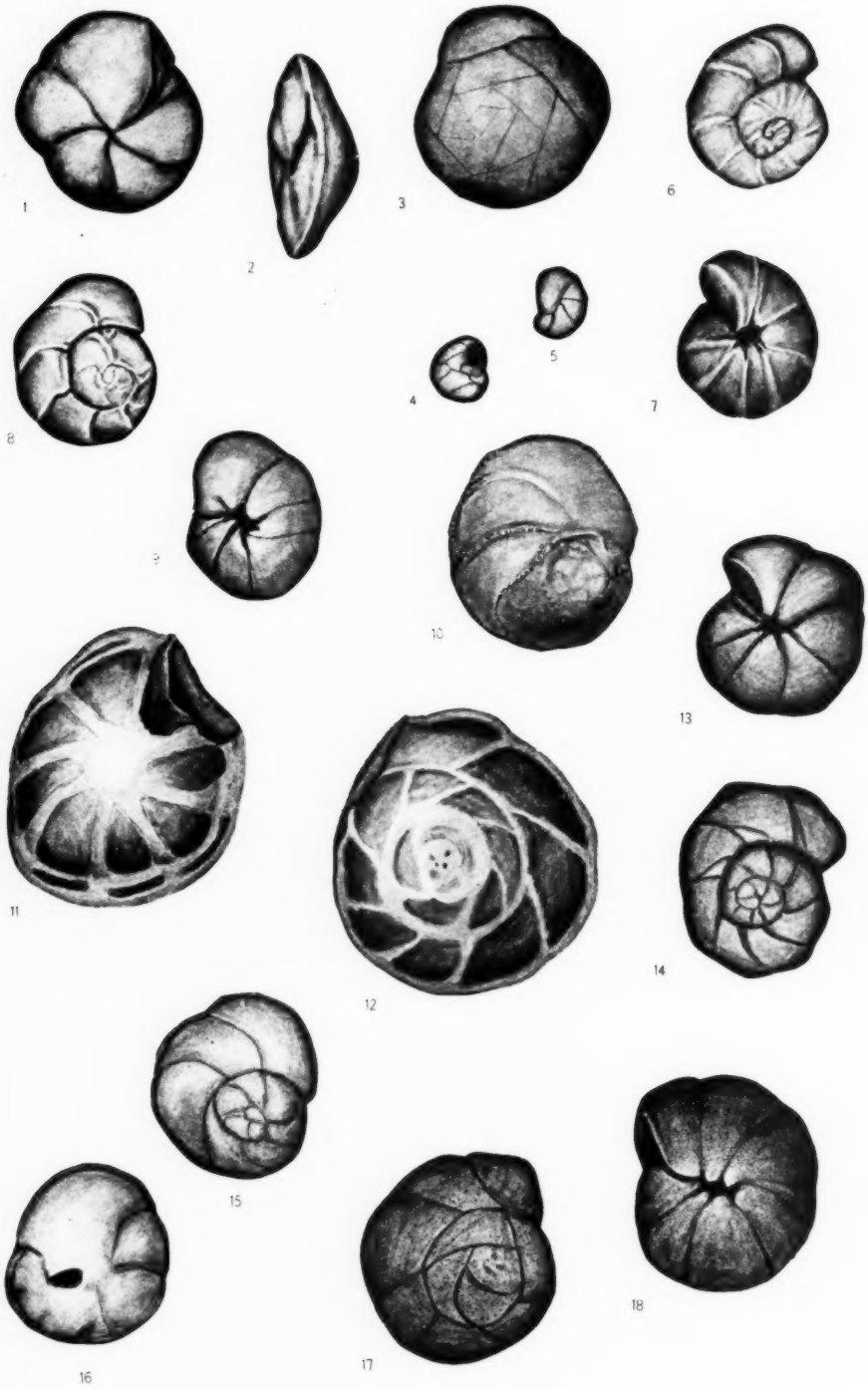
EXPLANATION OF PLATE 27

FIG. *1—Uvigerina subfusiformis* Hussey, n. sp., ×100. Holotype slide no. 2572, sample no. 137. (p. 132)
2—Angulogerina inflata Hussey, n. sp., ×100. Holotype slide no. 2574, sample no. 136. (p. 133)
3—Reusella costata Hussey, n. sp., ×100. Holotype slide no. 2570, sample no. 137. (p. 133)
4–5—Nodosarella elongata Hussey, n. sp., ×98. Holotype slide no. 2575, sample no. 171; paratype slide no. 2576, sample no. 156. (p. 135)
6–7—Robertina howei Hussey, n. sp., ×100. Holotype slide no. 2564, sample no. 185. (p. 131)
8—Virgulina spinulosa Hussey, n. sp., ×102. Holotype slide no. 2568, sample no. 137. (p. 134)
9—Entosolenia vasiformis Hussey, n. sp. ×95. Holotype slide no. 2566, sample no. 123. (p. 133)
10—Gümbelina multicellaris Hussey, n. sp., ×98. Holotype slide no. 2562, sample no. 137. (p. 130)
11—Virgulina regularis Hussey, n. sp., ×100. Holotype slide no. 2568, sample no. 137. (p. 134)
12—Uvigerinella subquadrata Hussey, n. sp., ×100. Holotype slide no. 2571, sample no. 118. (p. 131)
13—Siphogenerina spinulosa Hussey, n. sp., ×100. Holotype slide no. 2573, sample no. 137. (p. 132)
14–15—Discorbis parra Hussey, n. sp., ×100. Holotype slide no. 2577, sample no. 166. (p. 135)
16, 17—Siphonides biserialis Feray, ×146. Hypotype slide no. 2587, sample no. 110. (p. 138)
18, 19—Bolivina striata Hussey, n. sp., ×62. Holotype slide no. 2569, sample no. 186. (p. 134)
20, 21—Discorbis petalana Hussey, n. sp., ×75. Holotype slide no. 2578, sample no. 207. (p. 135)
22, 23—Cibicides discorbisiformis Hussey, n. sp., ×100. Holotype slide no. 2601, sample no. 169. (p. 142)
24—Bulimina rotunda Hussey, n. sp., ×95. Holotype slide no. 2565, sample no. 137. (p. 131)



Hussey, Eocene Foraminifera



Hussey, Eocene Foraminifera

simple, with a well developed neck and lip.

Dimensions of holotype No. 2575 from Sample No. 137, LaSalle Parish, La.: length 0.52 mm.; diameter 0.16 mm.

This species and *U. subfusiformis* undoubtedly belong to the same stock as both are very similar in the early stage. But they are easily distinguished by the different arrangements of their chambers.

Samples 13, 16, 19, 22, 35–42, 45, 47–49, 51, 52, 60, 61, 64–66, 76, 77, 102, 110, 111, 115, 118, 137, 140, 146, 148, 160, 161, 163, 166, 167 172, 188–190, 195, 208, 210, 211, 213.

Genus ANGULOGERINA Cushman, 1927
ANGULOGERINA INFLATA Hussey, n. sp.
Plate 27, figure 2

Test subfusiform, triserial, roundly triangular in transverse section; chambers indistinct in early stage, later ones distinct, somewhat inflated but not enough to destroy triangular shape; sutures distinct, especially in adult stage, depressed; wall calcareous, hyaline, covered with fine, short spines, perforate; aperture a round opening at the end of a well developed neck, with a phialine lip.

Dimensions of holotype No. 2574 from Sample No. 136, LaSalle, Parish, La.: length 0.34 mm.; greatest diameter 0.19 mm.

This distinctive species is a good index fossil for the Cane River formation. It is abundant, easy to identify, and does not, to the author's knowledge, occur either in older or younger beds. It occurs in the Weches formation.

Samples 3–5, 7–34, 100, 102, 107, 116, 118–121, 123–125, 127–134, 136, 137, 145, 146, 150, 184, 190, 202, 205–211.

Genus REUSSELLA Galloway, 1933
REUSSELLA COSTATA Hussey, n. sp.
Plate 27, figure 3.

Test distinctly triangular in transverse section, broadest at apertural end; chambers arranged triserially; sutures indistinct; wall calcareous, ornamented by heavy longitudinal costae which obscure the sutures and individual chambers; aperture elongate, somewhat comma-shaped, extends from near base of chamber to apex of test.

Dimensions of holotype No. 2570 from Sample No. 137, LaSalle Parish, La.: length 0.31 mm.; greatest width 0.15 mm.

This distinctive species occurs abundantly throughout the greater part of the Cane River formation. If it were not so small it might serve as a good index fossil for the formation.

Samples 10, 16–23, 25, 29–37, 41, 42, 45, 47, 54, 55, 57–62, 102, 111, 119, 120, 123–125, 127–129, 132, 137, 152, 153, 155, 157, 158, 160–162, 164, 172, 183, 186, 190, 195, 196, 205, 206, 208–214.

Genus ENTOSOLENIA Ehrenberg, 1848
ENTOSOLENIA VASIFORMIS Hussey, n. sp.
Plate 27, figure 9

Test a single chamber, elliptical in out-

EXPLANATION OF PLATE 28

FIGS. *1–3—Pulvinulinella bella* Hussey, n. sp., ×66. Holotype slide no. 2592, sample no. 211. (p. 140)

4, 5—Cassidulina parva Hussey, n. sp., ×66. Holotype slide no. 2593, sample no. 118. (p. 140)

6, 7—Gyroidina limbata Hussey, n. sp., ×66. Holotype slide no. 2580, sample no. 175. (p. 136)

8, 9—Ceratobulimina limbata Hussey, n. sp., ×66. Holotype slide no. 2591, sample no. 123. (p. 139)

10—Lamarckina claibornensis Cushman, var. *gemmulata* Hussey, n. var., ×66. Holotype slide no. 2589, sample no. 126. (p. 136)

11, 12—Epistomina chromata Hussey, n. sp., ×66. Holotype slide no. 2582, sample no. 1. (p. 137)

13, 14—Valvulineria gracilis Hussey, n. sp., ×66. Holotype slide no. 2579, sample no. 165. (p. 135)

15, 16—Lamarckina claibornensis Cushman, ×66. Hypotype slide no. 2588, sample no. 129. (p. 136)

17, 18—Eponides simplex Hussey, n. sp., ×66. Holotype slide no. 2581, sample no. 137. (p. 137)

line, compressed, internal tube free at bottom end visible from exterior; wall calcareous, smooth, unornamented, translucent; periphery keeled; aperture terminal, an elliptical slit.

Dimensions of holotype No. 2566 from Sample No. 123, LaSalle Parish, La.: length 0.14 mm.; width 0.11 mm.

This species is fairly abundant. Its simplicity of form is probably its most distinctive feature. It is present in the Weches formation.

Samples 11, 21, 23, 26–34, 37, 38, 42, 43, 47, 53–57, 59, 61, 64, 66, 68, 109, 111, 118, 123–125, 128, 137, 148, 150, 157, 165, 174, 196, 197, 211.

Genus VIRGULINA d'Orbigny, 1826
VIRGULINA SPINULOSA Hussey, n. sp.
Plate 27, figure 8

Test elongate, considerably compressed; chambers biserial; periphery slightly jagged due to extension of chambers in spine-like projections beyond chamber below; sutures distinct, slightly depressed, wall calcareous, finely perforate, smooth, translucent; aperture terminal, loop-shaped.

Dimensions of holotype No. 2567 from Sample No. 152, LaSalle Parish, La.: length 0.32 mm.; width 0.09 mm.

This species can be identified by the spine-like terminations of the chambers which give a jagged outline to the periphery.

Samples 35, 42, 55, 57–61, 63, 71, 75–77, 108, 151, 152, 155, 156, 161, 163–165, 169, 186, 190, 194, 196, 213.

VIRGULINA REGULARIS Hussey, n. sp.
Plate 27, figure 11

Test elongate, fusiform, compressed; chambers slightly inflated, arranged spirally in early stage, later chambers biserial; sutures distinct, slightly depressed; wall calcareous, hyaline, translucent, perforate; aperture a narrow, loop-shaped opening extending from apex of test to base of last formed chamber.

Dimensions of holotype No. 2568 from Sample No. 137, LaSalle Parish, La.: length 0.51 mm.; width 0.13 mm.

Samples 3–5, 7, 8, 10, 11, 16, 18–23, 29–31, 33, 35, 40–48, 53–56, 66–68, 75, 76, 102, 108, 109, 114, 120, 121, 123, 127, 128, 130–132, 137, 148–152, 155, 156, 163, 168, 171, 172, 184, 185, 190, 191, 193, 202, 204, 205, 207, 210.

Genus BOLIVINA d'Orbigny, 1839
BOLIVINA STRIATA Hussey, n. sp.
Plate 27, figures 18, 19

Test elongate, tapering, nearly circular in transverse section; chambers biserially arranged; sutures slightly depressed, notched, noticeably so in the more adult portion of the test; wall calcareous, distinctly perforate, ornamented by low, longitudinal ribs which extend almost the length of the test; aperture nearly terminal, ovate to somewhat loop-shaped.

Dimensions of holotype No. 2569 from Sample No. Ru. 503-B-186, Natchitoches Parish, La.: length 0.56 mm.; diameter 0.13 mm.

This is a distinctive species of the lower part of the greensand member of the Cane River formation. The striations, the notched sutures and the nearly circular transverse section are its most characteristic features.

Samples 4, 9, 24, 75–77, 79, 137, 161, 163, 164, 166, 186, 195–197, 204, 206, 208, 209, 212, 214.

BOLIVINA TAYLORI Howe

Bolivina taylori Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 67, pl. 9, figs. 9, 10.

Small specimens apparently identical with those described from the Cook Mountain formation of Louisiana are common in the Cane River Eocene.

Samples 3, 4, 7–12, 14–39, 41–43, 45–47, 53, 54, 56–60, 62–64, 68, 75, 76, 78, 102, 104, 105, 107–109, 111–116, 118–121, 123–125, 127–137, 144, 145, 150, 155, 157, 184, 186, 188–194, 197, 199, 201, 202, 204–213, 216, 217, 219.

Genus LOXOSTOMA Ehrenberg, 1854
LOXOSTOMA CLAIBORNENSE Cushman

Loxostoma claibornense Cushman, Cushman Lab. Foram. Res. Spec. Pub. 6, 1936, p. 59, pl. 8, figs. 15 a, b; Cushman Lab. Foram. Res. Spec. Pub. 9, 1937, p. 175, pl. 20, figs. 23, 24. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 68, pl. 9, fig. 11.

This species appear to be identical with the one reported from the Cook Mountain formation of Louisiana. It is present in the Weches formation.

Samples 3–5, 9, 10, 12, 13, 15–23, 26–33,

35–43, 45–48, 50, 51, 53, 55–65, 100, 102, 104, 105, 109, 111–116, 118–120, 123, 125, 127, 128, 130, 132–135, 137, 139, 144, 145, 148–153, 155–165, 184–186, 188–192, 196, 199, 201, 202, 204–208, 210–214, 216, 217, 219.

Genus BITUBULOGENERINA Howe, 1934

BITUBULOGENERINA ELLISI Howe

Bitubulogenerina ellisi Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 69, pl. 8, figs. 36, 37.

This species is rare in the Cane River formation. It appears to be identical with the one described from the Cook Mountain Eocene.

Samples 32, 34, 62, 146, 153.

Family ELLIPSOIDINIDAE

Genus NODOSARELLA Rzehak, 1895

NODOSARELLA ELONGATA Hussey, n. sp.

Plate 27, figures 4, 5

Test elongate, slightly tapering, very early chambers biserial, later uniserial chambers constitute about five-sixths of the whole test; chambers fairly numerous, subovate longitudinally, round in cross section; sutures distinct, flush with wall in biserial stage, depressed in uniserial portion; wall calcareous, hyaline, finely perforate; aperture terminal, narrow, semi-elliptical with a small overhanging, hood-like lip.

Dimensions of holotype No. 2575 from Sample No. 171, LaSalle Parish, La.: length 0.77 mm.; greatest diameter 0.11 mm.

Dimensions of paratype No. 2576 from Sample No. 156, LaSalle Parish, La.: length 0.66 mm.; greatest diameter 0.11 mm.

This species may be confused with some forms of *Nodosaria* which occur in the Cane River assemblage. It is abundant but not outstanding enough to be used as an index fossil for that part of the Cane River greensand in which it occurs. It is present in the Weches formation.

Samples 61, 63, 64, 66, 150, 153, 156, 157, 163, 164, 168.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS PARVA Hussey, n. sp.

Plate 27, figures 14, 15

Test very small for the genus, concavo-convex in transverse section; chambers numerous, arranged in trochoid coil; sutures distinct, slightly depressed on ventral side, raised on dorsal side; wall calcareous, vitreous, finely perforate, unornamented; aperture distinct, on dorsal side, uncovered.

Dimensions of holotype No. 2577 from Sample No. 166, LaSalle Parish, La.: greater diameter 0.14 mm.; lesser diameter 0.11 mm.

The small size of this species is probably its most distinctive feature but also it is easily identified by its shape and chamber arrangement.

Samples 11, 42–44, 47, 53, 61–63, 141, 194.

DISCORBIS PETALANA Hussey, n. sp.

Plate 27, figures 20, 21

Test planoconvex, subelliptical in outline, last few chambers definitely keeled; chambers few, only about nine or ten visible on dorsal side, increase rapidly in size as added, greatest width lies along periphery, somewhat inflated; sutures distinct, slightly limbate, depressed; wall calcareous, hyaline, distinctly perforate; umbilical margin on ventral side, partially concealed by extension of last formed chamber.

Dimensions of holotype No. 2578 from Sample No. Ru. 518-J-207, Natchitoches Parish, La.: greater diameter 0.40 mm.; lesser diameter 0.30 mm.

Superficially this species resembles *Cibicides discorbisiformis* but close inspection shows that the two belong to different genera. It is present in the Weches formation.

Samples 46, 47, 51, 56, 58, 71, 151, 161, 163, 164, 172–174, 184, 186, 190, 191, 196, 197, 204, 208, 209, 211–214.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA GRACILIS Hussey, n. sp.

Plate 28, figures 13, 14

Test trochoid, closely coiled, broadly convex on dorsal side, sharply convex and umbilicate on ventral side; chambers distinct, numerous; sutures depressed on ventral side, limbate and raised in early portion on dorsal side, depressed slightly in adult stage; wall calcareous, hyaline, very finely perforate; aperture on ventral side, extending from umbilicus almost to periphery, concealed by thin plate over its entire length.

Dimensions of holotype No. 2579 from Sample No. 165, LaSalle Parish, La.: diameter 0.40 mm.; thickness 0.20 mm.

This species has been referred to *Valvulineria* on the basis of the plate over the aperture and its close resemblance to species of *Gyroidina*.

Samples 34, 58, 60, 61, 63, 65, 70, 91, 95, 190, 206, 211, 212.

Genus LAMARCKINA Berthelin, 1881
LAMARCKINA CLAIBORNENSIS Cushman
Plate 28, figures 15, 16

Lamarckina marylandica Cushman, var. *claibornensis* Cushman, Cushman Lab. Foram. Research, Contr., vol. 2, pt. 1, 1926, p. 10.
Lamarckina claibornensis Cushman and Thomas, Jour. Paleontology, vol. 3, 1929, p. 180, pl. 24, figs. 1 a–c.

The following description is from Cushman and Thomas:

Test calcareous, finely perforate, planoconvex composed of two and a half coils showing on the convex dorsal side, and last coil and small umbilicus showing on flat ventral side; periphery moderately sharp, circular and not lobate; sutures distinctly limbate on dorsal side giving characteristic ornamentation, sutures practically obsolete on ventral side leaving surface smooth; aperture, a slit reaching from the comma-like umbilicus to the periphery. Length 0.42 mm.; width 0.40 mm.; thickness 0.15 mm.

Locality.—Two miles east of Alto, Cherokee County, Texas.

Range.—Mt. Selman greensand of Eocene.

U. S. Nat. Mus. Coll. No. 371022.

In the Cane River formation this species varies from forms that are typically rather large, ventrally fairly flat, dorsally broadly arched, with limbate, only slightly raised sutures, to others which are smaller in diameter, quite highly arched on the dorsal side, with distinctly raised sutures. The species is confined to the greensand member of the formation.

Dimensions of hypotype No. 2588 from Sample No. 129, LaSalle Parish, La.: diameter 0.39 mm.; thickness 0.20 mm. It is presenting the Weches and Enterprise formations.

Samples 29–31, 117, 125, 129, 145, 146, 186, 192–194, 196, 213, 214.

LAMARCKINA CLAIBORNENSIS Cushman
var. GEMMULATA Hussey, n. var.
Plate 28, figure 10

The variety differs from the typical form of the species only in that it has distinctly beaded sutures.

Dimensions of holotype No. 2589 from Sample No. 126, LaSalle Parish, La.: diameter 0.44 mm.; thickness 0.20 mm. It is present in the Weches formation.

Samples 31, 126, 129, 146, 193, 194, 214.

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA LIMBATA Hussey, n. sp.
Plate 28, figures 6, 7

Test trochoid, distinctly convex on ventral side, slightly so on dorsal side, close-coiled, umbilicate on ventral side; chambers fairly numerous, distinct; transverse sutures distinct, limbate, raised; spiral suture a depressed channel; wall calcareous, semiporcellaneous; aperture a low arched slit extending from the umbilicus nearly to the periphery, not concealed.

Dimensions of holotype No. 2580 from Sample No. 175, LaSalle Parish, La.: diameter 0.38 mm.; thickness 0.21 mm.

This abundant and easily identified species is an excellent index fossil for the Cane River formation. It is the only *Gyroidina* known to the author, that has raised sutures. It is present in the Enterprise formation.

Samples 4, 5, 9, 23–27, 29–35, 41, 63, 64, 68, 70, 75, 79, 80, 82–87, 90, 95, 100, 102, 124, 127–130, 133, 135, 136, 141, 142, 146, 165, 167–169, 172–177, 179, 192–197, 213.

GYROIDINA SOLDANII d'Orbigny
var. OCTOCAMERATA
Cushman and G. D. Hanna

Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna, Proc. Calif. Acad. Sci., 4th ser., vol. 16, no. 8, 1927, p. 223, pl. 14, figs. 16–18. Cole, Bull. Am. Paleontology, vol. 14, no. 51, 1927, p. 29, pl. 2, figs. 22–24. Weinzierl and Applin, Jour. Paleontology, vol. 3, 1929, p. 406. Cushman and Thomas, Jour. Paleontology, vol. 4, 1930, p. 40, pl. 4, figs. 2, 3. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 75, pl. 9, figs. 34–36.

This species occurs throughout the Cane River formation, but it is most abundant in the greensand marl member.

Samples 2, 25, 27, 29–32, 34, 37, 39, 47, 49, 50, 64, 79, 91, 92, 114, 117, 135, 137, 143, 145, 146, 150, 151, 178–181, 207–211, 213, 214, 219.

Genus EPONIDES Montfort, 1808
EPONIDES SIMPLEX Hussey, n. sp.
Plate 28, figures 17, 18

Test trochoid, broadly arched on dorsal side, distinctly convex but umbilicate on ventral side; chambers indistinct in early stage; sutures limbate in early portion, later depressed, distinct; wall calcareous, hyaline, distinctly perforate; aperture an arched opening extending from near the umbilicus almost to the periphery, hooded but not concealed by a thin plate-like extension of the last formed chamber.

Dimensions of holotype No. 2581 from Sample No. 137, LaSalle Parish, La.: diameter 0.48 mm.; thickness 0.26 mm.

This species is easy to distinguish from the more elaborate forms of *Eponides* by its more simple shape. It is not so flat or even concave ventrally as some variations of *E. mexicana*, nor so highly convex dorsally as *E. guayabalensis*. It is present in the Weches formation.

Samples 1, 5, 7, 9, 14–18, 20–23, 26, 31, 33, 35–39, 41–44, 46–48, 50, 51, 53, 54, 68, 71, 74, 80, 81, 83–87, 90, 91, 95, 97, 98, 102, 107, 108, 110, 113, 116, 118–121, 123–125, 127, 130, 131, 133–135, 137, 139, 144–146, 148–150, 152, 153, 156, 158–160, 178, 179, 181, 185, 186, 188–190, 192–196, 199, 201–208, 210, 211, 213, 215, 217.

EPONIDES MEXICANA (Cushman)

Pulvinulina mexicana Cushman, Bull. Am. Assoc. Petroleum Geologists, vol. 9, no. 2, 1925, p. 300, pl. 7, figs. 7, 8.
(?) *Eponides mexicana* Cushman, Jour. Paleontology, vol. 1, no. 2, 1927, p. 165, pl. 26, figs. 6, 7.
Eponides guayabalensis Cole, Bull. Am. Pal., vol. 14, no. 51, 1927, p. 29, pl. 2, figs. 18, 19, 20.
Eponides patelliformis Stadnichenko, Jour. Paleontology, vol. 1, 1927, p. 232, pl. 38, figs. 6–8.
Eponides guayabalensis Cushman and Thomas, Jour. Paleontology, vol. 3, no. 2, 1929, p. 180, pl. 23, figs. 6 a–c.
Eponides mexicana Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 75, pl. 9, figs. 31–33, pl. 10, figs. 1–3.

This species is abundant in the upper half of the Cane River formation, and present in the Weches formation.

Samples 3–5, 7–10, 12, 14, 16–33, 35–50, 52, 53, 100, 107, 109, 111, 112, 114, 118, 123–125, 127–129, 135, 136, 148, 150, 151, 153, 155–159, 184, 185, 187, 189, 191, 202, 205, 207, 210, 217, 218.

GENUS EPISTOMINA Terquem, 1883
EPISTOMINA CHROMATA Hussey, n. sp.
Plate 28, figures 11, 12

Test almost equally biconvex, closely coiled, trochoid, umbilical area closed with a plug; chambers numerous, seven or more in adult whorl; sutures limbate, only very slightly raised, very distinct; wall calcareous, usually colored (either dark tan with cream colored sutures and peripheral apertures or iridescent), very finely perforate; aperture multiple, the main one in the apertural face a large comma-shaped opening, other openings form a series of narrow slits parallel with and just ventral to the periphery.

Dimensions of holotype No. 2582 from Sample No. 116, LaSalle Parish, La.: diameter 0.54 mm.; thickness 0.28 mm.

The distinctive features of this species are the colored test, and the striking manner in which the sutures stand out as a result of this coloring. To date the author has noted this species only in the Cane River formation. It is present in the Weches.

Samples 8–10, 14, 16, 18–23, 29, 32, 34, 100, 107, 114–119, 121, 123, 124, 127, 129, 134–136, 144–146, 185, 192.

Genus SIPHONINA Reuss, 1850
SIPHONINA UMBONATA Hussey, n. sp.
Plate 29, figures 2, 3

Test closely coiled, trochoid, biconvex, early chambers on dorsal side concealed by a large, glassy knob, other chambers distinct, slightly inflated; sutures distinct where not covered, depressed; wall calcareous, hyaline, coarsely perforate; aperture elongate, slightly twisted from peripheral line, with very short neck and well developed flaring lip.

Dimensions of holotype No. 2584 from Sample No. 109, LaSalle Parish, La.: diameter 0.39 mm.; thickness 0.21 mm.

The distinctive feature of this species is the large, glassy knob present in the central portion of the dorsal side. There is a strong tendency toward the development of a uniserial stage and several specimens were found in which the final chamber had departed from the coiled stage. It may well be

that there may be found in the Cane River formation specimens which are true representatives of *Siphoninella* that have developed from this species. It is present in the Weches formation.

Samples 3–5, 7–15, 18, 19, 21–24, 26, 31–37, 39–43, 45, 47, 49–51, 53–68, 70–74, 76–80, 83–87, 90, 91, 95, 96, 100, 102, 109–112, 114, 116–120, 123–125, 127–131, 133–137, 141, 145, 146, 148, 150–153, 155–158. 160–162, 164, 166–175, 177, 179, 180, 184–193, 195–197, 199, 201–214, 216, 217.

SIPHONINA HOWEI Cushman
Plate 29, figures 8, 9

Siphonina howei Cushman, Proc. U. S. Nat. Mus., vol. 72, Art. 20, 1927, p. 4, pl. 3, fig. 6 a–c.

The following description is quoted from Cushman:

Test small, nearly circular, nearly equally biconvex, much compressed, periphery angled, sharply acute and with distinctly serrate keel, lobulate, chambers usually six in the last-formed volution, the last few very slightly inflated on both sides; sutures distinct, depressed, slightly limbate, very slightly curved; wall distinctly spinose with short blunt spines and the periphery very serrate; aperture broadly elliptical, occupying nearly the whole height of the last-formed chamber, with a distinctly thickened lip and short neck.

Diameter, 0.30 mm.; thickness, 0.10 mm.

Holotype.—(Cushman coll. 6726) from Lower Claiborne, Cane River formation at Natchitoches, La. This species is named for Dr. Henry V. Howe, who has done much work on the paleontology of Louisiana.

This species is easily distinguished by its high degree of ornamentation and much compressed test.

The spines which are so conspicuous and of comparatively large diameter in this species are hollow and seem to extend well down into the test. Where broken off they produce a coarsely pitted appearance.

Dimensions of hypotype No. 2585 from Sample No. 113, LaSalle Parish, La.: diameter 0.30 mm.; thickness 0.14 mm.

Samples 10–24, 26, 27, 29, 32–34, 41, 42, 44, 46, 47, 51, 56, 58, 59, 65–67, 69–71, 73–75, 77, 100, 102, 110–113, 115, 119–121, 123, 125, 127, 128, 130, 132, 134, 135, 139, 140, 143–146, 150, 159, 163, 192–195, 202, 203, 206, 210–214, 219.

SIPHONINA CLAIBORNENSIS Cushman

Siphonina claibornensis Cushman, U. S. Nat. Muc. Proc., vol. 72, 1927, p. 4, pl. 3, figs. 5 a–c; Cushman and Thomas, Jour. Paleontology, vol. 3, 1929, p. 181, pl. 24, figs. 2 a–c; Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 76, pl. 10, figs. 4–6, 10, 11.

This characteristic species is most abundant in the upper part of the Cane River formation. It is present in the Weches and Enterprise formations.

Samples 3–5, 7–10, 23, 45–47, 49, 50, 75, 76, 107–110, 113, 115, 143, 144, 149, 164, 185, 186, 199, 201, 204–206, 212, 216.

Genus SIPHONINELLA Cushman, 1927
SIPHONINELLA PARVA Hussey, n. sp.
Plate 29, figure 1

Test in early stages trochoid, closely coiled, three blunt spines on periphery of each chamber in coiled portion; later, greater part of test uncoiled, chambers added in linear uniserial series; chambers not numerous, five or six usually in uniserial portion, distinct; sutures indistinct in coiled part, distinct, deeply depressed in uniserial part; wall calcareous, hyaline, decorated by a row of short blunt spines just above the base of each chamber; aperture terminal, round, with short neck and heavy lip.

Dimensions of holotype No. 2586 from Sample No. Ru. 518-J-207, Natchitoches Parish, La.: length 0.57 mm.; width 0.10 mm.

The relatively small size of this species and the comparatively great length of the uniserial portion of the test make this a very distinctive member of the genus *Siphoninella*. It is fairly abundant but too small and fragile to be important as an index fossil for the Cane River formation.

Samples 41, 43–45, 47, 150–153, 184, 185, 191, 204–208, 210, 216.

Genus SIPHONIDES Feray
SIPHONIDES BISERIALIS Feray
Plate 27, figures 16, 17

Siphonides biserialis Feray, Jour. Paleontology, vol. 15, no. 2, 1941, 174–175, figs. 1–4.

This species, although too small to be a good index fossil, is very distinctive and appears to be confined to the Cane River formation and its equivalents. It is most abundant in the upper part of the Cane River.

Samples 5, 6, 10–12, 14, 16, 17, 22–25, 30–36, 107, 110, 123–125, 127, 128, 130, 132.

Family AMPHISTEGINIDAE
Genus ASTERIGERINA d'Orbigny, 1839
ASTERIGERINA TEXANA (Stadnichenko
Plate 29, figures 13, 14

Eponides texana Stadnichenko, Jour. Paleontology, vol. 1, 1927, p. 232, pl. 38, figs. 1–5.
Asterigerina texana Cushman and Thomas, Jour. Paleontology, vol. 3, 1929, p. 181, pl. 24, figs. 5 a–c.

The following description is quoted from Cushman and Thomas:

Shell calcareous, finely perforate, comparatively large, plane-convex, composed of about three and a half coils, those near the center covered by a smooth, transparent boss which partly hides the sutures of the first chambers, dorsal side flat in many specimens but convex in many others, ten to twelve chambers in the last whorl; ventral side with small raised boss and the last coil showing, and having the secondary sutures developed giving a distinct star pattern so characteristic of this genus, ventral side usually papillose especially near the aperture which is covered by these decorations in almost all specimens. Length 0.68 mm.; width 0.60 mm.; thickness 0.33 mm.

Locality.—One mile north of Elkhart near railroad at Hopkins fault, Anderson County, Texas.

Range.—Mt. Selman greensand of Eocene.

U. S. National Museum Collection No. 371023.

This species is confined to the greensand member of the Cane River formation. A very few specimens have been found in the *Discocyclina advena* zone, but it is otherwise absent except near the base of the greensand where it occurs in greatest abundance, almost to the exclusion of all other species. It is present in the Weches and Enterprise.

Dimension of hypotype No. 2590 from Sample No. 181, LaSalle Parish, La.: diameter 0.46 mm.; thickness 0.23 mm.

Samples 14, 49, 87, 93, 95–98, 102, 111, 143, 158, 160, 179–181, 188, 190, 191, 207, 208, 210, 211, 213, 218, 219.

Family CASSIDULINIDAE
Genus CERATOBULIMINA Toula, 1915
CERATOBULIMINA LIMBATA Hussey, n. sp.
Plate 28, figures 8, 9

Test of about medium size for the genus, close coiled, trochoid, biconvex, dorsal side deeply umbilicate; chambers distinct on both sides, seven or eight in last formed volution, inflated; sutures distinct on both sides, sharply depressed on the ventral side, distinctly limbate and with decided angle on the dorsal side, spiral-suture distinct, depressed; wall smooth, semi-porcellaneous, polished, finely perforate; aperture a large arched opening in apertural face extending from the umbilicus to near the periphery, but almost entirely hidden in well preserved specimens by a thin plate-like extension of the last formed chamber.

Dimensions of holotype No. 2591 from Sample No. 123, LaSalle Parish, La.: diameter 0.34 mm.; thickness 0.25 mm.

This species resembles *C. exima* but it differs markedly in the limbate, raised character of its dorsal sutures, the covering of the aperture, its comparatively smaller size, and because all chambers are clearly visible on the dorsal side and all chambers in the last whorl are visible on the ventral side. It is present in the Weches formation.

Samples 1, 3, 7–10, 12–14, 18, 20–24, 26–29, 100, 102, 107, 109, 110, 113–115, 118, 119, 123–125, 127, 128, 131, 133, 146, 185–187, 192, 193, 195, 203, 211–215.

CERATOBULIMINA EXIMIA (Rzehak)

Pulvinulina eximia Rzehak, Ann. k. k. Nat. Hofmuseums, vol. 3, pt. 3, 1888, p. 263, pl. 11, figs. 7 a–c.
Ceratobulimina eximia Toula, Jahrb. Geol. Geol. Reichsanst., vol. 64, 1920, p. 665. Cushman and Harris, Contrib. Cushman Lab. Foram. Res., vol. 3, pt. 4, 1927, p. 174, pl. 29, figs. 3, 4; pl. 30, figs. 12–16. Stadnichenko, Jour. Paleontology, vol. 1, 1927, p. 233, pl. 38, figs. 9–11. Cole, Bull. Am. Pal., vol. 14, no. 53, 1928, p. 220 (20). Cushman and Thomas, Jour. Paleontology, vol. 3, no. 2, 1929, p. 182, pl. 24, figs 3, a–c.
Rotalia dorri Cole, Bull. Am. Pal., vol. 14, no. 51, 1927, p. 29, pl. 4, figs. 5, 6. .
Certatobulimina eximia Howe, Louisiana Geol. Geol. Survey Bull. No. 14, 1939, p. 80, pl. 11, figs. 12, 13.

This species has been reported from the Claiborne Weches formation of Texas and from the Cook Mountain of Louisiana. It is fairly common in the upper two-thirds of the Cane River Eocene formation.

Samples 3, 5, 7–11, 13–16, 18–25, 30, 32–34, 38, 41, 42, 44, 54, 57, 59, 61, 102, 107–121, 123–125, 127–129, 134–137, 145, 146, 148, 185, 187, 196, 104, 115, 116.

Genus CASSIDULINA d'Orbigny, 1826
CASSIDULINA PARVA Hussey, n. sp.
Plate 28, figures 4, 5

Test subglobular, closely coiled, involute; chambers indistinct, alternate on both sides of and extending across the periphery; sutures indistinct, very slightly depressed; aperture a comparatively large comma-shaped opening just to one side of and subparallel to the periphery.

Dimensions of holotype No. 2593 from Sample No. 118, LaSalle Parish, La.: longer diameter 0.14 mm.; short diameter 0.11 mm.

Samples 9, 16, 19, 21, 23–25, 31–33, 35–38, 40–45, 47, 55–61, 63, 111–114, 118, 121, 123–125, 127–130, 132, 134, 135, 150, 152, 153, 161, 165.

Genus PULVINULINELLA Cushman, 1926
PULVINULINELLA BELLA Hussey, n. sp.
Plate 28, figures 1–3

Test closely coiled, trochoid, above average size for the genus, subcircular in outline in dorsal view; chambers distinct, about six in last volution, very slightly umbilicate on ventral side; sutures distinct, slightly depressed, radial on ventral side, flush with surface, oblique on dorsal side; wall calcareous, smooth, subvitreous; aperture just ventral of periphery, somewhat loop-shaped, begins parallel to periphery and extends toward the umbilicus.

Dimensions of holotype No. 2592 from Sample No. Ru. 518-N-211, Natchitoches Parish, La.: diameter 0.41 mm.; thickness 0.19 mm.

The comparatively large size and trim, compact appearance of this species are its distinctive features. It is present in the Weches formation.

Samples 29, 35–37, 42, 43, 45, 51, 55–57, 59, 61, 63–65, 67, 68, 70, 72–76, 79, 90, 91, 141, 142, 152, 156–158, 161, 163, 165, 166, 168, 169, 171–173, 184, 186, 188–197, 207–214, 218, 219.

PULVINULINELLA EXIGUA (H. B. Brady) var. OBTUSA (Burrows and Holland)

Pulvinulina exigua H. B. Brady var. *obtusa* Burrows and Holland, Proc. Geol. Assoc., vol. 14, 1897, p. 49, pl. 2, fig. 25. Plummer, Univ. Texas Bull. 2644, 1926, p. 151, pl. 11, figs. 2 a–c.

Pulvinulinella exigua (H. B. Brady) var. *obtusa* Cushman and Ponton, Contrib. Cushman Lab. Foram. Res., vol. 8, pt. 3, 1932, p. 71, pl. 9, figs. 9 a–c.

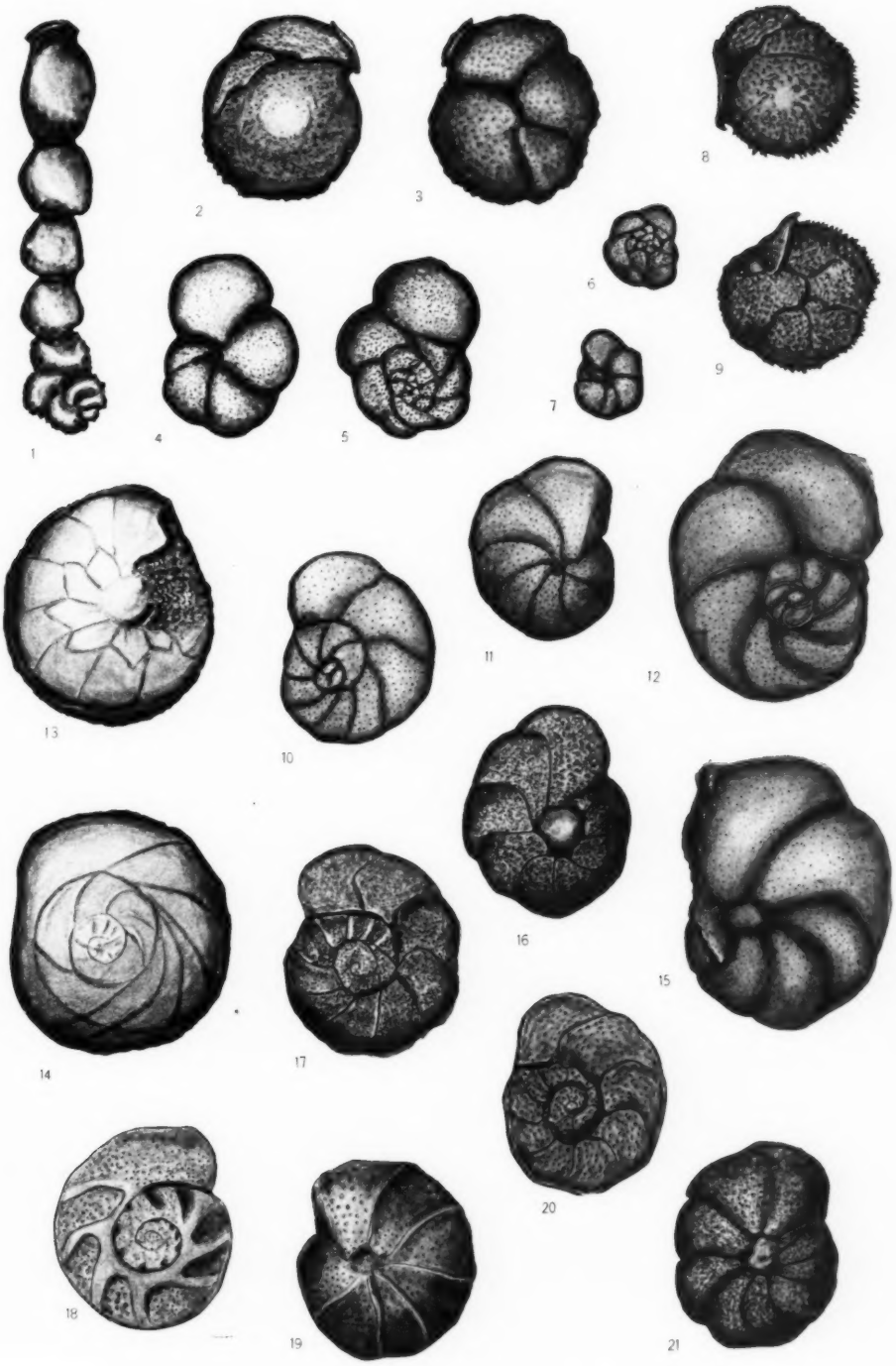
Pulvinulinella exigua (H. B. Brady) var. *obtusa* Louisiana Geol. Survey Bull. No. 14, 1939, p. 81, pl. 11, figs. 4–6.

The discovery of this species in the Cane River formation bridges the gap between its previously recorded occurrences in the Midway and Wilcox and in the Cook Mountain sediments. It is present in the Weches formation.

Samples 33, 40, 54–59, 61–63, 71, 83, 108, 139, 143, 144, 151, 153, 170, 171, 177, 180, 192, 206, 208–212, 214.

EXPLANATION OF PLATE 29

FIG. *1—Siphoninella parva* Hussey, n. sp., ×100. Holotype slide no. 2586, sample no. 207. (p. 138)
2, 3—Siphonina umbonata Hussey, n. sp., ×69. Holotype slide no. 2586, sample no. 109. (p. 137)
4, 5—Globorotalia inflata Hussey, n. sp., ×69. Holotype slide no. 2594, sample no. 137. (p. 141)
6, 7—Globorotalia perforataminuta Hussey, n. sp. ×69. Holotype slide no. 2595, sample no. 181. (p. 141)
8, 9—Siphonina howei Cushman, ×69. Hypotype slide no. 2585, sample no. 113. (p. 138)
10, 11—Cibicides glabratus Hussey, n. sp., ×69. Holotype slide no. 2597, sample no. 174. (p. 142)
12, 15—Cibicides mcguirti Hussey, n. sp., ×69. Holotype slide no. 2602, sample no. 175. (p. 143)
13, 14—Asterigerina texana (Stadnichenko) ×69. Hypotype slide no. 2590, sample no. 181. (p. 139)
16, 17—Cibicides mammiformis Hussey, n. sp., ×69. Holotype slide no. 2590, sample no. 10. (p. 142)
18, 19—Cibicides umbilicatus Hussey, n. sp., ×69. Holotype slide no. 2600, sample no. 174. (p. 142)
20, 21—Cibicides submammiformis Hussey, n. sp., ×69. Holotype slide no. 2603, sample no. 185. (p. 143)



Hussey, Eocene Foraminifera

Family GLOBIGERINIDAE
Genus GLOBIGERINA d'Orbigny, 1826
GLOBIGERINA TOPILENSIS Cushman

Globigerina topilensis Cushman, Contrib. Cushman Lab. Foram. Res., vol. 1, no. 1, 1925, p. 7, pl. 1, figs. 9 a–c. Cole, Bull. Am. Pal., vol. 14, no. 51, 1927, p. 33; Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 84, pl. 12, figs. 1–3.

This is a fairly common species which ranged through the Cane River formation. It is present in the Weches formation.

Samples 4, 9, 15, 17, 18, 20–23, 25–41, 43, 44, 46–50, 52–54, 56–58, 60, 62–65, 68, 71, 74, 76, 78–80, 82, 83, 85–87, 89, 102, 109–111, 113–121, 123–125, 127–130, 133–137, 141, 144–146, 148–150, 153, 158–161, 164, 167, 172, 175, 176, 179, 184, 185, 189–191, 195, 202, 204, 205, 207, 209–211, 213.

Family GLOBOROTALIIDAE
Genus GLOBOROTALIA Cushman, 1927
GLOBOROTALIA INFLATA Hussey, n. sp.
Plate 29, figures 4, 5

Test trochoid, closely coiled, nearly flat on dorsal side, strongly convex ventrally, deeply umbilicate; chambers numerous, distinct, strongly inflated especially in later stage; sutures distinct, slightly depressed; wall calcareous, thin, coarsely perforate aperture a large opening extending into umbilicus, partially covered by lip.

Dimensions of holotype No. 2594 from Sample No. 137, LaSalle Parish, La.: long diameter 0.38 mm.; thickness 0.26 mm.

This species occurs with such great abundance in the lower part of the Cane River formation that it is used in economic work to mark the approach of the Cane River-Wilcox contact. It greatly resembles some species of *Globigerina* but has been referred to *Globorotalia* on the basis of its close coiling and the character of its aperture. It is present in the Weches formation.

Samples 3–5, 7–9, 15–23, 25–34, 37, 39–44, 47, 49, 50, 51, 54, 55, 57, 59, 61–63, 65, 66, 69, 71–73, 75–79, 102, 111, 112, 115, 116, 118–120, 123–125, 127, 128, 130, 132, 134, 135, 137, 139, 149, 150, 152, 155, 161, 165, 172, 176, 183, 184, 197, 201, 202, 205, 206, 208, 210–214, 217, 219.

GLOBOROTALIA PERFORATAMINUTA
Hussey, n. sp.
Plate 29, figures 6, 7

Test small for the genus, trochoid, biconvex, umbilicate; periphery acute to slightly keeled; chambers in early portion indistinct, later distinct, slightly inflated; sutures distinct in later stage, slightly depressed; wall calcareous, hyaline, quite coarsely perforate for the size of the species; aperture on ventral side, large, extends into umbilicus, almost completely hidden by lip.

Dimensions of holotype No. 2595 from Sample No. 123, LaSalle Parish, La.: diameter 0.19 mm.; thickness 0.11 mm.

The small size and comparatively coarse perforations distinguish this species.

Samples 16–23, 29–37, 40, 48–52, 54–60, 63–67, 69, 71–73, 75, 76, 78–82, 84–87, 91, 92, 94–96, 107, 110–112, 129, 130, 132, 140, 144, 145, 159, 160, 162, 164, 167, 169, 171, 174, 178, 185, 190, 191, 195–197, 199, 201–206, 208–214.

GLOBOROTALIA CENTRALIS Cushman and Bermudez

Globorotalia centralis Cushman and Bermudez, Contrib. Cushman Lab. Foram. Res., vol. 13, pt. 1, 1937, p. 26, pl. 2, figs. 62–65; Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 84, pl. 12, figs. 4–6.

These specimens appear to be identical with the Cook Mountain species. They are fairly common throughout most of the Cane River formation. It is present in the Weches formation.

Samples 4, 9, 15, 17, 19–23, 32, 34, 43, 45, 46, 48, 59, 61, 64, 65, 71, 102, 108, 111, 115, 118, 121, 123, 125, 127–129, 132, 133, 137, 141, 145, 146, 148, 150, 153, 157, 164, 165, 179, 185, 187, 189, 190, 192–196, 204, 206–208, 215.

Family ANOMALINIDAE
Genus ANOMALINA d'Orbigny, 1826
ANOMALINA UMBONATA Cushman

Anomalina umbonata Cushman, Bull. Am. Assoc. Petroleum Geologists, vol. 9, 1927, p. 300, pl. 7, figs. 5, 6; Cushman, Jour. Paleontology, vol. 1, 1927, p. 170, pl. 27, figs. 10, 11. Cole, Bull. Am. Pal., vol. 14, no. 51, 1928, p. 35. Weinzierl and Applin, Jour. Paleontology, vol. 3, no. 4, 1929, p. 409, Nuttall, Jour. Paleontology, vol. 4, no. 3, 1930, p. 275. Howe, Louisiana Geol.

Survey Bull. No. 14, 1939, p. 86, pl. 13, figs. 9–11.

This species occurs more or less abundantly throughout the Cane River formation of Louisiana. It is present in both Weches and Enterprise.

Samples 7, 9, 10, 16–35, 41–45, 47, 50, 51, 60, 63, 75, 76, 80–83, 100, 102, 107, 110–116, 118–120, 123–125, 127–130, 133–137, 143, 145, 146, 148, 150, 157, 164, 179, 185, 186, 190, 191, 197, 204, 207–211, 215.

Genus CIBICIDES Montfort, 1808

CIBICIDES GLABRATUS Hussey, n. sp.
Plate 29, figures 10, 11

Test plano-convex, closely coiled, trochoid; chambers slightly inflated, about seven in the last formed whorl; sutures indistinct, slightly depressed; wall calcareous, smooth very finely perforate, hyaline, a small glassy knob in center of ventral side; aperture extends from periphery back along base of one or more chambers on dorsal side.

Dimensions of holotype No. 2597 from Sample No. 174, LaSalle Parish, La.: long diameter 0.29 mm.; short diameter 0.31 mm.; thickness 0.13 mm.

The characteristic feature of this species is its smooth wall and lack of coarse perforations. It is present in the Weches formation.

Samples 12, 40, 46, 48–50, 55, 56, 60, 63, 68, 74–76, 90, 140, 156, 169, 172, 176, 186, 193, 195, 208, 210.

CIBICIDES MAMMIFORMIS Hussey, n. sp.
Plate 29, figures 16, 17

Test trochoid, plano-convex, mammiform; periphery with slight tendency toward development of a keel; chambers on ventral side distinct only in adult stage, all distinct on dorsal side; sutures slightly depressed; wall calcareous, distinctly perforate, decorated with a rounded knob over umbilicus on ventral side; aperture typical for the genus.

Dimensions of holotype No. 2599 from Sample No. Ru. 226-190, Natchitoches Parish, La.: diameter 0.38 mm.; thickness 0.14 mm.

The general mammiform shape of this species is its most distinctive feature.

It is present in the Weches formation.

Samples 43–47, 63–65, 68, 70, 71, 75, 76, 78, 79, 81–85, 91, 139, 140, 150–152, 155, 158, 163, 165–171, 174, 184, 185, 188–191, 193–197, 205–211, 214, 128, 219.

CIBICIDES UMBILICATUS Hussey, n. sp.
Plate 29, figures 18, 19

Test unequally biconvex, closely coiled, trochoid; chambers distinct on both sides, only those of last formed whorl visible on ventral side; sutures distinct, limbate, raised on both ventral and dorsal sides, spiral suture also raised; wall calcareous, distinctly perforate, slight but distinct depression in umbilicus on ventral side; aperture typical for the genus, extending across periphery and back along base of last formed chamber.

Dimensions of holotype No. 2600 from Sample No. 174, LaSalle Parish, La.: diameter 0.40 mm.; thickness 0.19 mm.

This species is easy to distinguish by its biconvex shape, limbate raised sutures, and depressed umbilicus.

It is present in the Weches and Enterprise formations.

Samples 8, 14, 31, 33, 35, 37, 40, 42, 71, 74, 75, 87, 102, 140, 141, 143, 151, 167, 170–172, 174–176, 194–196, 205, 207, 210–214, 219.

CIBICIDES DISCORBISIFORMIS Hussey, n. sp.
Plate 27, figures 22, 23

Test rather loosely coiled, slightly concavo-convex, trochoid; chambers distinct on both sides, with all visible only from dorsal side, nine or more in last formed whorl, distinctly inflated; sutures distinct, depressed; wall calcareous clear, vitreous, perforate, a small glassy knob fills umbilicus; aperture extends from the periphery along the base of the last formed chamber.

Dimensions of holotype No. 2601 from Sample No. 169, LaSalle Parish, La.: long diameter 0.38 mm.; short diameter 0.30 mm. thickness 0.09 mm.

In general form this species resembles *Discorbis* but its aperture shows that it must be referred to *Cibicides*.

Samples 5, 40, 41, 43, 48–50, 53–58, 60, 61, 68, 102, 107, 110–113, 139, 140, 149, 150, 165, 169, 170, 172, 173, 186, 189, 191, 192.

CIBICIDES MCGUIRTI Hussey, n. sp.
Plate 29 figures 12, 15

Test plano-convex, trochoid, somewhat loosely coiled; periphery acute to slightly keeled, lobate; chambers inflated ventrally, distinct, about eight in last formed whorl, rapidly increasing in size as added; sutures slightly limbate, distinct, depressed; wall calcareous, distinctly perforate, smooth, vitreous, a small glassy knob fills umbilicus on ventral side; aperture extends across periphery and back along base of last formed chamber.

Dimensions of holotype No. 2602 from Sample No. 175, LaSalle Parish, La.: long diameter 0.54 mm.; short diameter 0.44 mm.; thickness 0.14 mm.

This species is fairly large and distinctive but it is not sufficiently abundant to be a good index fossil of the Cane River formation. It is named in honor of Dr. J. W. McGuirt of the Tidewater Oil Co., Houston, Texas.

It is present in the Enterprise formation.

Samples 68, 75, 140, 170, 195, 196, 207, 208.

CIBICIDES SUBMAMMIFORMIS Hussey, n. sp.
Plate 29, figures 20, 21

Test trochoid, closely coiled, slightly biconvex, somewhat complanate; periphery acute to slightly keeled, slightly lobate; chambers distinct, about nine in last formed whorl, increasing in size moderately; sutures distinct, slightly depressed, very definitely angled posteriorly near periphery; wall calcareous, distinctly perforate, small knob fills umbilicus on ventral side; aperture extends across periphery back to umbilicus on ventral side and along base of last chamber on dorsal side.

Dimensions of holotype No. 2603 from Sample No. Ru. 510-D-185, Natchitoches Parish, La.: diameter 0.40 mm.; thickness 0.13 mm.

This species resembles *C. mammiformis* but it is somewhat compressed and slightly biconvex instead of plano-convex.

It is present in the Weches formation.

Samples 43–50, 52–55, 57, 59, 61–65, 68, 71, 78–83, 86, 87, 92, 93, 95, 152, 153, 155–158, 165–169, 171–175, 177, 184–186, 189, 192–197, 205–208, 211, 214, 217, 219.

CIBICIDES WESTI Howe

Cibicides westi Howe, Louisiana Geol. Surv. Bull. No. 14, 1939, p. 99, pl. 13, figs. 20–22.

This species, described from the Cook Mountain Eocene of Louisiana, ranges through the Cane River formation. It is present in the Enterprise formation.

Samples 4, 9, 16–26, 30, 32, 35, 38, 40, 42, 47, 50–52, 54–59, 61–64, 68, 71, 74, 83, 85–89, 91, 93, 102, 107, 120, 123–125, 127, 134, 137, 139, 140, 150, 160, 161, 163, 184, 204, 205, 210, 211, 214.

CIBICIDES SASSEI Cole

Cibicides sassei Cole, Bull. Am. Pal., vol. 14, no. 51, 1927, p. 35, pl. 4, figs. 10, 11. Cushman and Thomas, Jour. Paleontology, vol. 3, no. 2, 1929, p. 182, pl. 24, figs. 4 a–c. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 88, pl. 13, figs. 18, 19.

Samples 17, 19, 21, 35, 50, 61.

Family ORBITOIDIDAE
Genus DISCOCYCLINA Gumbel, 1868
DISCOCYCLINA ADVENA (Cushman)

Orthophragmina advena Cushman, U. S. Geol. Survey Pub. Paper 128, 1921, p. 139, pl. XXII, figs. 1–5.

Discocyclina advena Vaughan, Bull. Geol. Soc. America, vol. 35, 1924, pp. 785–822, pls. 30–36.

The following is the original description:

Test circular, compressed, center depressed, surrounded by a thicker excentric area, beyond which toward the periphery the test again becomes thinner; unequally biconvex, one side usually being flatter than the other; the surface comparatively smooth, slightly granular, representing the peripheral ends of slender pillars.

Diameter 5 to 7 millimeters.

Vertical sections show the general form of the test, with a concave thin center, thickening and then thinning again toward the periphery, and the very narrow band of equatorial chambers, which increase but slightly toward the periphery. The numerous vertical chambers are largest in the thickest portion of the test, where they are separated by numerous small pillars.

Horizontal sections show the equatorial chambers, two in number, both circular, excentric, the wall of the smaller coinciding with the wall of the larger, so that the larger chamber forms with it a complete circle; equatorial chambers rectangular, nearly square, annuli being very numerous but close together, much more so than in other American species of *Orthophragmina*.

Type specimen, U.S.N.M. No. 328252, from Natchitoches, La.: L. C. Johnson, collector. At this station the species is very abundant. Large numbers of this species were collected by T. W.

Vaughn at U.S.G.S. stations 2914, near Provencal Natchitoches Parish, La., and 3570, "Foraminifera horizon" of the *Ostrea sellaeformis*.

Samples 37–41, 43–46, 48–51, 53, 149–153, 155–158, 218, 219.

DISCOCYCLINA PERPUSILLA Vaughan

Discocyclina clarki Cole, Bull. Am. Pal., vol. 14, no. 51, 1927, p. 36, pl. 2, fig. 31 (not *Orthophragmina clarki* Cushman).

Discocyclina perpusilla Vaughan, U. S. Nat. Mus. Proc., vol. 76, art. 3, 1929, p. 9, pl. 2, figs. 3, 4, 5, 5a. Gravell and Hanna, Bull. Am. Assoc. Petroleum Geologists, vol. 22, no. 8, 1938, p. 1008. Howe, Louisiana Geol. Survey Bull. No. 14, 1939, p. 89, pl. 14, figs. 8, 9.

This species, reported from the Cook Mountain Eocene of Louisiana by Howe, occurs abundantly in limited zones in the Cane River Eocene formation.

Samples 43, 45, 47, 53–55, 57, 60, 64, 68, 151, 152, 155–158, 168, 169, 190, 210.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 145–160, 1 TEXT FIG., MARCH, 1949

THE AGE OF THE *HANNATOMA* MOLLUSK FAUNA OF SOUTH AMERICA[1]

A SYMPOSIUM

ABSTRACT—The *Hannatoma* fauna is an assemblage of marine and brackish-water mollusks present in Tertiary strata at several widespread points in northwestern South America. The distinctiveness and wide geographic range of the fauna combine to make it important in stratigraphic correlation, but its value in this respect has been impaired by difference of opinion as to whether its age is middle Oligocene, as originally claimed, or upper Eocene. The seven papers in this symposium comprise the response to a circular requesting current opinions as to the age of the *Hannatoma* fauna. Different aspects of the age-relationships of associated mollusks and Foraminifera in Venezuela, Colombia, Ecuador and Peru are discussed. The authors conclude that the *Hannatoma* fauna occurs mainly in upper Eocene but locally in Oligocene beds.

INTRODUCTION

THE *Hannatoma* fauna is an assemblage of marine and brackish-water mollusks known from several Tertiary formations in northwest South America. In its first detailed description by A. A. Olsson (1931)[2] correlation was made with the fauna of the Middle Oligocene Antigua formation. This age assessment has usually been accepted without comment (e.g. Davies 1934, Notestein *et al.* 1944, Sutton 1946) despite the modification of Olsson's Peruvian time-scale by Wiedey and Frizzell (1939), but in more than one instance an anomaly has arisen because beds considered Middle Oligocene on the basis of the *Hannatoma* fauna must be dated as Upper Eocene on alternative evidence.

Such anomalies are undesirable and this one is especially troublesome because the *Hannatoma* fauna is the sole age-criterion of certain Tertiary formations. It would seem that either the *Hannatoma* fauna must be a facies-controlled assemblage ranging from late Eocene into the Oligocene, or else its assessment as Middle Oligocene in Peru must be out of accord with established biochronology in the Caribbean region. To test current opinion R. M. Stainforth undertook to circularize geologists and paleontologists familiar with the problem, requesting from them objective statements on the age of the fauna in areas which they had studied. The seven statements which follow comprize the response to this canvass. Based on age-relationships partly of mollusks and partly of Foraminifera in Venezuela, Colombia, Ecuador and Peru, the following conclusions are reached:

(1) In the Venezuela-Colombia borderland known records of the *Hannatoma* fauna are all from Upper Eocene beds.

(2) In the northern Peru-southern Ecuador region some occurrences are in Eocene, others in Oligocene beds.

(3) The presence of the main elements of the *Hannatoma* fauna signifies a brackish or semi-brackish facies and and is not an accurate guide to geologic age.

As indicated in the text, the field and laboratory data discussed in this symposium are drawn mainly from the geological files of certain oil companies operating in South America. Thanks are due to these companies for permitting publication of these data.

[1] Manuscript received 1948.

[2] For details of references see list at the end of the symposium.

AGE OF THE CARBONERA FORMATION NEAR CÚCUTA, COLOMBIA

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In 1944 A. A. Olsson (in Notestein *et al.* 1944, pp. 1199–1201), expressed the opinion that the megafauna of the Carbonera formation as exposed in the vicinity of Cúcuta is of Middle Oligocene age and he correlated it with the *Hannatoma* fauna of northern Peru.

In 1946 several collections from the locality referred to by Olsson (El Cerrito, 7 km. northeast of Cúcuta) were received in the Bogota Paleontological Laboratory of the Tropical Oil Company. The present author examined them and identified the species at that time. From these identifications and from a review of the literature, it appears probable that this fauna should be referred to the Upper Eocene and not to the Oligocene as was done by Olsson. The reasons for this older age assignment are, first, the older age now assigned to some of the Peruvian faunas with which Olsson correlated the Carbonera fauna, and, second, the different identifications of some of the species and the recognition of additional species found in the Tropical Oil Company collections.

The greater age of the Peruvian beds is accepted for several reasons. Olsson (1930, p. 18) accepted Cushman's determination of the age of *Discocyclina peruviana* as Upper Eocene and this strongly influenced his conclusions. He considered his Talara and Saman formations to be referable to the Upper Eocene and the succeeding Chira shale to be Oligocene. Subsequently Wiedey and Frizzell (1939, p. 528) and Vaughan (1945, pp. 95, 104) have shown that *Discocyclina peruviana* is of upper Middle Eocene age. Also Wiedey and Frizzell have placed the Chira shale and part of the Mancora formation of Olsson in the uppermost Eocene. Clark (Clark and Durham, 1946, p. 9) is in agreement with Wiedey and Frizzell that the Chira shale is uppermost Eocene. Durham (Clark and Durham, 1946, p. 78) has recorded a coral, *Turbinolia olssoni* Wells, originally described from the Mancora formation, from the Upper Eocene of the El Carmen area in Colombia. Thus it is apparent that part, if not most, of Olsson's Lower and Middle Oligocene (the Chira shale and Mancora formation) is now considered by authors other than Olsson to be of uppermost Eocene age, and consequently any age determination based on a faunal correlation with those beds should be changed to Upper Eocene.

The Upper Eocene age of the Carbonera formation, however, is not based entirely on this change in the age assignment of the Peruvian beds. Examination of the fauna recently collected shows the presence of forms not seen by Olsson, and also some of his species have been differently identified. The new material comes from three localities, not far distant from one another, Tropical Oil Company localities Nos. 18603, 18605, 18607. The combined faunal list is as follows:

Anomia sp.

Arca (*Argina*) *samanensis* Olsson (?)
Specimen not well preserved, but apparently very closely allied to, if not identical with Olsson's (1929, p. 71, pl. 9, figs. 4, 5) species from the Saman formation of Peru.

Cerithiella sp.
Related to *C. heckscheri* Palmer (1937, p. 227, pl. 29, figs. 1, 5, 6, 13, 14) from the lower Claiborne of the Gulf Coast.

Crommium palmerae Clark
Two specimens of this species described (Clark and Durham, 1946, p. 18, pl. 15, figs. 2, 4, 13, 16) from the uppermost Eocene of the El Carmen, Bolivar, area.

Hannatoma emendorferi Olsson
This is Olsson's *Hannatoma* n. sp. (in Notestein *et al.*, 1944, p. 1199, pl. 4, figs. 1–3), but our specimens show no difference from the type of the above species, as figured from the Mirador sandstones and conglomerates of Peru (correlated with the Mancora formation by Olsson, 1931, p. 109.)

Harrisianella sp.
Related to *H. peruviana* Olsson (1929, pp. 86–87, pl. 8, fig. 7), described from the Restin and Saman formations of Peru.

Lagunitus (?) sp.
This is Olsson's *Cerithium* n. sp. (in Notestein *et al.*, 1944, p. 1199). It appears to be related to *Telescopium* (?) *samanense* Olsson (1928, p. 117, pl. 20, figs. 2, 3) from the Saman formation of Peru now referred to *Lagunitus* by Olsson (1929, p. 86) but differs by having a more rounded base and less prominent spiral cords.

Melongena sp. A
This is *Melongena* n. sp. *1* of Olsson (in Notestein *et al.*, 1944, pp. 1199, 1200, pl. 4, fig. 6). It has no known near relative.
Melongena sp. B
This is *Melongena* n. sp. *2* of Olsson (in Notestein *et al.*, 1944, p. 1200, pl. 4, fig. 7). It is related to *M.* (*Pugilina*) *subcarinata* (Lamarck) (Cossmann and Pissaro, 1910–13, pl. 39, figs. 191–3) from the Upper Eocene (Bartonian) of the Paris Basin.
Ostrea sp.
Oliva sp.
Phacoides sp.
Pitar spp.
Two or more species are present.
Polinices sp.
Pseudofaunus sp.
This is Olsson's *Pseudofaunus bravoensis* (in Notestein *et al.*, 1944, p. 1201), but the specimens available do not agree with the types as figured by Olsson (1931, p. 182, pl. 27, figs. 9, 11).
Turritella sp.
This species is closely related to *T. chira* Olsson (1928, pp. 112–113, pl. 19, fig. 5) from the Talara formation of Peru. No other described form is similar to it.

In the preceding list of 17 species one (*Crommium palmerae* Clark) is known elsewhere only from Upper Eocene strata; six species are most closely related to well established Middle or Upper Eocene species; two species (*Hannatoma emendorferi* and *Pseudofaunus* sp.) are identified with or compared to species from beds which Olsson considered Oligocene in age, but which other workers now generally place in the Upper Eocene; and seven species have no apparent close affinities or age significance. Thus the preponderance of evidence is in favor of an Eocene age for this fauna even though Olsson's age assignment of the Chira shale and Mancora formation of Peru to the Oligocene is retained. As noted by Notestein *et al.*, (1944, p. 1199), H. S. Ladd had previously considered the Carbonera fauna to be of Upper Eocene age.

Olsson (1940, p. 280) has summarized what he termed the "Hannatoma Fauna" which he considered to be important in correlating the Oligocene formations of tropical America. The most characteristic elements listed by him include *Pseudofaunus bravoensis* Olsson, *Hannatoma gesteri* (Hanna and Israelsky), *H. tumbezia* Olsson, and *Ampullinopsis spenceri* Cooke. It is noteworthy that all these species are indicative of at least somewhat brackish water and they are therefore facies fossils. For this reason it does not appear to the present author that much reliance should be placed on their occurrence except for correlation in a very broad way.

THE *HANNATOMA* FAUNA IN COLOMBIA AND VENEZUELA

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The writer's first experience with the problem of the age of the *Hannatoma* fauna came in connection with compilation of data concerning paleontology, stratigraphic age and correlation for the paper by Frederick A. Sutton (1946) entitled "Geology of Maracaibo Basin, Venezuela." At that time Dr. Axel A. Olsson had been acting as consulting paleontologist for the Creole Petroleum Corporation, and his opinion that the *Hannatoma* fauna is of Middle Oligocene age was accepted without much question. The 1939 paper by L. W. Wiedey and D. L. Frizzell entitled "Revision of the Eocene Stratigraphy of Northwestern Peru" was not then available, and although it was known from Frizzell's 1943 paper and from conversations with Dr. Hans Thalmann that the Chira formation must be included in the Upper Eocene, we had no intimation that any part of the Mancora formation had ever been considered other than Middle Oligocene. Since *Hannatoma emendorferi* Olsson and *Faunus* (*Pseudofaunus*) *bravoensis* Olsson were both recorded from the Mancora, we considered these species indicative of Middle Oligocene age when we encountered them in Venezuela and Colombia, disregarding the opinion of H. S. Ladd (in Notestein *et al.*, 1944, p. 1199) that the *Hannatoma* fauna of the Carbonera formation in the Department of Santander del

Norte, Colombia, is Upper Eocene because this view was not supported by specific identifications.

Shortly after publication of his paper, Sutton received a letter from the geological department of the Colombian Petroleum Company, operating in the Barco Concession, maintaining the Upper Eocene age of the *Hannatoma* fauna of the Carbonera formation at the El Cerrito locality near Cúcuta, Santander del Norte. A further exchange of letters resulted in the addition of Phillip P. Wolcott of the Creole Petroleum Corporation to a Tropical Oil Company field party headed by Luis G. Morales, which was working the area along the boundary between the State of Táchira, Venezuela, and the Department of Santander del Norte, Colombia. This party during the first half of 1947 was able to trace the Upper Eocene Omuquena formation of Táchira across the border into the Carbonera formation of Santander del Norte and the overlying Upper Eocene Lobaterita formation of Táchira across the border into the Leon formation of Santander del Norte. In addition Wolcott brought back the best collection of Omuquena and Carbonera macrofossils we have ever obtained from this area. The writer has identified a portion of them but had to discontinue this work due to more urgent research. Results to date indicate an Upper Eocene age. Macrofossils from the two best Colombian localities are listed below.

Creole Serial Sample No. 54,000; El Cerrito, 7 kilometers northeast of Cucuta, Santander del Norte; Carbonera formation

Ostrea sp.
Olsson in Notestein *et al.*, 1944.

Carolia sp.
Synonyms: *Anomia* n. sp. Olsson in Notestein *et al.*, 1944, Carbonera formation; *Anomia* sp. Winkler in Sutton, 1946, Omuquena formation. Davies (1934) lists occurrences of this genus in the Middle and Upper Eocene of Egypt, Algeria, Jamaica and Peru, and questionably in the Oligocene of Florida.

Mactra sp.
Olsson in Notestein *et al.*, 1944. Synonym: *Mactra* sp. Clark, 1946, Upper Eocene of El Carmen district, Bolivar, Colombia.

Pitar (*Pitarella*) *colombiana*
Clark, 1946, Upper Eocene of El Carmen district, Bolivar, Colombia.

Pitar sp.
Olsson in Notestein *et al.*, 1944.

Tellina sp.
Olsson in Notestein *et al.*, 1944.

Polinices n. sp.
Olsson in Notestein *et al.*, 1944.

Neverita bolivarensis
Clark, 1946, Middle and Upper Eocene of El Carmen district, Bolivar, Colombia.

Turritella aff. chira
Olsson in Notestein *et al.*, 1944. This form is actually a new species intermediate between *T. chira* Olsson and *T. samanensis* Olsson, both of which occur in the Upper Eocene of Peru and Colombia.

Cerithiella sp.
Olsson in Notestein *et al.*, 1944.

Harrisianella peruviana
Olsson, 1929, Middle and Upper Eocene of Peru.

Cerithium (*Perucerithium*) *cf. negritosense*
Woods in Bosworth, 1922, upper Middle Eocene of Peru. This is probably the same as *Cerithium* n. sp. Olsson in Notestein *et al.*, 1944.

Hannatoma emendorferi
Olsson, 1931, Upper Eocene, Mirador sandstone member of the Mancora formation of Peru. Synonym: *Hannatoma* n. sp. Olsson in Notestein *et al.*, 1944.

Cornulina sp. 1.
Synonym: *Melongena* n. sp. 1 Olsson in Notestein *et al.*, 1944.

Mazzalina sp.
This genus ranges from Paleocene to Upper Eocene.

Creole Serial Sample No. 54,003; Quebrada Seca, 9 kilometers northeast of Cúcuta, Santander del Norte; Carbonera formation

Arca (*Arginella*) *cf. puntabravoensis*
Olsson in Notestein *et al.*, 1944.

Ostrea sp.
Olsson in Notestein *et al.*, 1944.

Carolia sp.
See preceding list for synonyms and range.

Mactra sp.
Olsson in Notestein *et al.*, 1944, Synonym: *Mactra* sp. Clark, 1946, Upper Eocene of El Carmen district, Bolivar, Colombia.

Pitar (*Pitarella*) *colombiana*
Clark, 1946, Upper Eocene of El Carmen district, Bolivar, Colombia.

Pitar sp.
Olsson in Notestein *et al.*, 1944.

Transennella bolivarensis
Clark, 1946, Upper Eocene of El Carmen district, Bolivar, Colombia.

Clementia peruviana
Olsson, 1928, Middle Eocene to Upper Oligocene of Peru.

Tagelus bolivarensis
Clark, 1946, Upper Eocene, El Carmen district, Bolivar, Colombia. Synonyms: *Tagelus* sp. Olsson in Notestein *et al.*, 1944: *Psammosolen cf. sancti-dominici* Winkler in Sutton, 1946, Omuquena formation.

Macoma sp.
Winkler in Sutton, 1946, Omuquena formation.
Polinices n. sp.
Olsson in Notestein *et al.*, 1944.
Policines sp.
Winkler in Sutton, 1946, Omuquena formation.
Crommium palmerae
Clark, 1946, Upper Eocene, El Carmen district, Bolivar, Colombia.
Turritella aff. chira
Olsson in Notestein *et al.*, 1944; intermediate between *T. chira* and *T. samanensis*.
Turritella samanensis
Olsson, 1928, Upper Eocene of Peru and Colombia.
Cerithiella sp.
Olsson in Notestein *et al.*, 1944.
Harrisianella peruviana
Olsson, 1929, Middle and Upper Eocene of Peru.
Cerithium (*Perucerithium*) cf. *negritosense*
Woods in Bosworth, 1922, upper Middle Eocene of Peru.
Hannatoma emendorferi
Olsson, 1931, Upper Eocene, Mirador sandstone member of the Mancora formation of Peru. Synonym: *Hannatoma* n. sp. Olsson in Notestein *et al.*, 1944.
Melanatria aff. acanthica
Woods in Bosworth, 1922, Middle Eocene of Peru.
Cornulina sp. 1.
Synonym: *Melongena* n. sp. 1 Olsson in Notestein *et al.*, 1944.
Cornulina sp. 2.
Synonym: *Melongena* n. sp., sp. 2 Olsson in Notestein *et al.*, 1944.
Perufícus lagunitensis, var. charanalensis
Olsson, 1931, Upper Eocene of Peru, Chira and Mancora formations.
Lyria? sp.
Agaronia harrisi
Clark, 1946, Upper Eocene El Carmen district, Bolivar, Colombia.

It is interesting that Wolcott was unable to find any representative of the Bebedero formation of Táchira (described in Sutton's paper) in the Cúcuta area of Colombia due to Miocene overlap. Apparently the correlation of the Bebedero with the uppermost part of the Carbonera is erroneous. On the basis of heavy mineral correlation it still seems probable that the Bebedero, El Fausto and Icotea formations in the Venezuelan part of the Maracaibo basin should be referred to the Oligocene, although not necessarily to the Middle Oligocene. On the other hand, the La Victoria formation in the District of Miranda in the northeastern part of the State of Zulia, Venezuela, must be assigned to the Upper Eocene, because it contains *Hannatoma emendorferi* Olsson. Likewise the *Hannatoma emendorferi* beds in the Rio Boconó section on the boundary between the States of Portuguesa and Barinas in the Apure basin of Venezuela must now be considered Upper Eocene. Another interesting result is that because the Bebedero, El Fausto and Icotea formations were all deposited in fresh water, it may be assumed that the Maracaibo basin was free from marine invasion during the entire Oligocene.

THE *HANNATOMA* FAUNA IN COLOMBIA AND VENEZUELA

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A representative of the *Hannatoma* fauna was collected in 1927–1931 by Venezuela Gulf Oil Company geologists at the El Cerrito locality, seven kilometers northeast of Cúcuta. It was studied by H. S. Ladd who reported on it in a company report (July, 1931) as follows:

> A very similar fauna occurs in the Upper Eocene rocks of Santander del Norte and still farther to the west in the Esmeraldas formation of Santander. East of Táchira some of the same mollusks have been collected by geologists of the Lago Petroleum Corporation in the State of Zamora to the north of Barinas. The Upper Eocene section of Zamora has also yielded a number of characteristic Paují shale Foraminifera and Woodring (1927) has described an Upper Eocene marine limestone from the area north of Barinas. . . . The collections from Santander exhibit faunal differences but all probably belong to the same series. They are clearly Eocene in age, though it has not been possible to identify any of the species with published material. With the exception of *Melanatria* sp. *A*.[3] all of the species

[3] This name is being applied to a large and exceedingly variable group of shells. Five varieties have been discriminated, some of which may prove to be distinct species. L. W. Stephenson has reported *Hemisinus* from locality 110–31, but because I have no description of this genus available I am unable to check the identification. The species here tentatively referred to *Melanatria* may properly belong in the genus *Hemisinus*. H.S.L.

are new to the V.G.O. collections. This makes an exact age determination impossible, but the occurrence of *Melanatria* sp. *A* in four of the five localities is believed to be significant. This species (variety no. 3) has been collected from the adjoining Department of Santander del Norte (collections 47–27 and 48–27) where it is associated with an Upper Eocene fauna.

Other species from the Santander collections are related to (but not identical with) forms described from the older Eocene rocks in other parts of South America. The *Diastoma*, for example, is of the type of *D. americanum* described by Woods (1922) from the Negritos formation (Wilcox and lower Claiborne) of Peru and the *Turritella* is related to *T. anceps* Woods from the same formation. The occurrence of both these species coupled with the absence of the common *Corbicula* and *Melanatria* in locality 167–31 suggest that it may be pre-Jackson in age.

The Santander collections taken together do not form a typical marine fauna, but one which probably lived in an estuary or similar brackish water environment. Thus, *Melanatria* and *Telescopium* are fresh or brackish water shells while *Corbicula* and *Cyrena*, though supposedly marine, have close relatives such as *Batissa* which are inhabitants of fresh water. *Diastoma* and *Turritella* may both be marine genera, but the latter is often associated with brackish water shells in the younger Tertiary deposits of northern Venezuela. In the Santander collections these two genera are represented only by a few broken specimens. The small number of species and the complete absence of Foraminifera also suggest a non-marine environment.

The most valuable species which occurs in the two collections from Santander del Norte is *Potamides annulatus* (Douglas) (=*Hannatoma*. H. D. H.). It was originally described from the District of Miranda, State of Zulia[4] and also occurs in the adjoining District of Bolivar in rocks believed to be of Upper Eocene age. The species has also been reported from the State of Lara and the Lago geologists collected it north of Barinas in their "Bocono series" which is tentatively correlated by them with the Pauji shale. The exact relation of the beds carrying the *Potamides* (*Hannatoma*. H. D. H.) to Woodring's Upper Eocene limestone (Woodring, 1927) from the same area is not known.

The *Terebra* sp. *B*. which occurs in one of the collections from Santander del Norte is probably the same as one occurring in the type locality of the Rubio formation. The *Turritella* sp. *C* of 48-27 likewise occurs in the type locality of the Rubio formation and also in northern Venezuela in rocks believed to be Upper Eocene. The specimens identified as *Ostrea* cf. *inca* are related to the species originally described by Woods (1922) from the Negritos formation of Peru. The collections from Santander del Norte have yielded a more diversified fauna than those from Santander but one which includes, nevertheless, a number of shells capable of living in brackish water. Common examples are *Ostrea*, *Natica* and *Potamides*.

The specimens of *Polinices* (*Neverita*) *uamenensis* from the type locality of the Rubio formation appear to be identical with the type specimens figured and described by Olsson (1928, p. 59) from the Upper Eocene Saman formation of Peru. The *Mya* (*Raetomya*) sp. *A*. is identical with specimens collected from the Upper Eocene "Bocono series" by geologists of the Lago Petroleum Corporation in the area north of Barinas. The fish remains are rare and of a different type from those which are so widespread in the Cretaceous rocks of the same area.

Zamora material listed on Plate VI does not contain any very diagnostic species. The assemblage of genera is typically Eocene, however, and the *Rimella valerensis* is identical with specimens from the Upper Eocene of Trujillo. The collection numbered 44–27 contains only a questionable species of *Plicatula*, but after studying foraminifera from the same bed Hedberg reports that its age is "Eocene, probably Upper Eocene" (oral communication).

In 1932 I sent some specimens from the El Cerrito locality to Floyd Hodson who compared them with Axel Olsson's Middle Oligocene fossils from Peru. They were later sent to Olsson who definitely considered them Middle Oligocene on the basis of identity with a middle Oligocene fauna in Peru.

In 1937 during the Venezuelan Geological Congress in San Cristobal, attention was called to Olsson's determination of these fossils (see Kehrer 1938, p. 55) and as a result of discussion at that time an excursion was arranged whereby I took the whole Congress to the El Cerrito locality which is just across the border from the San Cristobal area, and a detailed fossil collection was made through the pooled efforts of all geologists present which was turned over to the Venezuelan Servicio de Geologia y Mineria for submission to an expert for study.

Another detailed collection from this locality was later made by the Colombian Petroleum Company which was submitted to Olsson and is the basis for his published report (in Notestein *et al.* 1944, pp. 1199–1201).

There is little doubt that the Carbonera formation of the El Cerrito locality is equivalent to beds which have been called "Sandy

[4] Douglas, J. G., Some Miocene mollusks from northwestern Venezuela. Manuscript filed as Gulf Report No. 184-A, p. 277, 1928. At the time of writing Douglas believed this species to be Miocene in age, but now agrees that the rocks of the type locality are Upper Eocene.

Shales" formation by the Shell geologists in Táchira, Venezuela, and referred to the Upper Eocene by them. It also seems probable that the strata at the El Cerrito locality (Carbonera formation) are equivalent to the Esmeraldas formation of Santander which has generally been considered to be of Eocene age.

Pilsbry and Olsson (1928) described fossils from the Los Chorros horizon in the upper part of the Esmeraldas formation which they considered as probably Upper Eocene in age. In general, on the basis of regional correlation, I would be inclined to favor an age older than Middle Oligocene for the *Hannatoma* fauna of the Santander del Norte area of Colombia.

NOTE ON THE STRATIGRAPHIC POSITION OF THE *HANNATOMA* ZONE IN THE WESTERN TÁCHIRA REGION, VENEZUELA

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Hannatoma similar to *H. emendorferi* has been recognized by W. P. Woodring (private report) from a locality situated 4 kilometers S 55° E of the town of San Antonio (State of Táchira) near the Colombian border. This fossil locality is situated in the northern branch of Quebrada Seca about 700 meters southwest of the ranch of Gamelote. The strata outcropping there belong to the lower part of the Sandy Shale formation on the southern end of the La Fila Anticline.

This area was mapped in detail in 1939 by W. G. C. Tomalin, geologist of the Shell interests in Venezuela, who established the position of the fossiliferous strata beyond doubt as being above the Mirador sandstone and Third Coal horizon, which outcrop both north and south of the Hannatoma bearing beds.

The lower Sandy Shale formation, reaching a thickness of about 480 meters, in this region consists mainly of nonmarine or lacustrine sediments such as sandstones, clays, shales and interbedded lignitic coal seams.

These strata have the same physical appearance and stratigraphic position as the corresponding beds of the Carbonera formation described by Notestein *et al.* (1944) from El Cerrito in the Cúcuta Basin (about 20 kilometers northwest of this locality) and of the Quebrada Carbonera, near the Venezuelan border (about 80 kilometers northwest of San Antonio). Four distinct fossiliferous limestones were mapped by Tomalin within the lower Sandy Shale formation in the Quebrada Seca area. According to him the *Hannatoma* zone (locality TN 7472) lies between his second and third limestones (Fig. 1). The faunas of these two limestones (localities TN. 6076 and TN. 6060 resp.) have been identified by Woodring (private report dated Washington, D. C. December 8th 1939) as follows:

TN. 6076 (Second limestone)
Gastropods:
Cerithiella sp.
Turritella aff. *samanensis* Olsson
"*Cornulina*"? (probably the species in TN. 6060)
Pleurofusia? sp.
Pelecypods:
Anomia? sp.
Lucina sp.
Diplodonta? sp.
Tellina? sp.
Spisula sp.
Clementia dariena vetula Woodring?
Pitar sp. (small species of *nuttalliopsis* group and an elongate variety)

TN. 6060 (Third limestone)
Gastropods:
Harrisianella? cf. *peruviana* Olsson
Cerithiella sp.
Turritella aff. *samanensis* Olsson
Neverita? sp.
"*Cornulina*" cf. *levifusoides* (Olsson)
Turridae, genus?
Aberospira? sp.
Pelecypods:
Anomia? sp.
Noetid genus?
"*Lucina*" sp.

[5] Acknowledgment for permission to publish this statement is hereby made to the Head Office of the Royal-Dutch Shell group in the Hague.

Tellina? sp.
Spisula sp.
Clementia dariena vetula Woodring?
Pitar sp. (small species of *nuttalliopsis* group and an elongate variety)
Raetomya? sp.
Corbula sp.

According to Woodring the collections from these two localities contain essentially the same fauna and are, therefore, inferred to represent essentially the same age. Some of the fossils are similar to Middle Eocene species, others closely resemble species from formations in Peru assigned to the upper Eocene. Woodring considered the fauna as late Middle or early Upper Eocene. Woodring stated that, the Hannatoma beds (Locality TN 7472) contain a *Hannatoma* similar to *H. emendorferi* from the Middle Oligocene of Peru. In Peru *Hannatoma* has been found only in the middle Oligocene and is recorded from strata of the same age in Colombia. If the genus is a reliable guide, locality TN 7472 represents Middle Oligocene. This genus is probably a brackish water fossil, however, and its stratigraphic range may be greater than is now apparent.

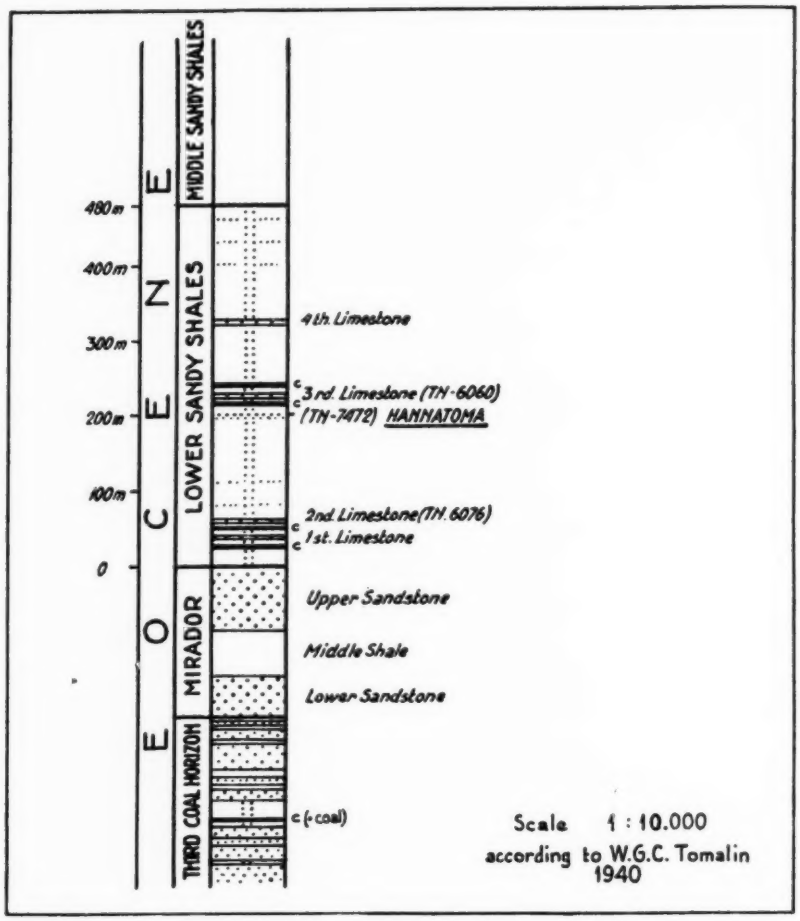

FIG. 1—Stratigraphic position of the *Hannatoma* level in Western Tachira.

From the above it seems more logical to conclude that the *Hannatoma* zone is Eocene rather than Oligocene in age because both the overlying and underlying faunas seem to indicate an Eocene age. This problem has

already been referred to by the writer in his paper on stratigraphy in the States of Táchira and Mérida (Kehrer 1938, footnote, p. 47), and it has also been discussed by Hedberg (p. 55, *op. cit.*). On the evidence from Quebrada Seca, which was unknown in 1938, the writer now definitely favors an Eocene age and does not see any reasons to change his original assignment of an Eocene age for the Sandy Shale and Mirador formations. Probably the range of *Hannatoma* is wider than assumed by Olsson and not strictly limited here to Middle Oligocene, as it may be in Peru.

The presence of an Eocene fauna in the Sandy Shale formation, overlying the Mirador Sandstone, makes Liddle's (1946, pp. 396–401) Lower Oligocene age assignment for the latter untenable.

Sutton (1946, p. 1689) recorded *Hannatoma emendorferi* Olsson from the Middle Oligocene La Victoria formation which he correlated with the Icotea formation (no indigenous fauna, but reworked Eocene Foraminifera), the El Fausto formation in Perijá (no age determining fossils) and the Bebedero formation in Northern Táchira (no fossils).

The Icotea formation, however, could also be considered, on the basis of Foraminifera and viewed more regionally, as a somewhat brackish and less typically marine facies of part of the Eocene Paují formation. It is also possible that the *Hannatoma* limestone of the Victoria might eventually be referred to the Eocene and be grouped with underlying beds of Eocene age. Although this correlation appears possible, it is, unfortunately, not yet substantiated by any absolute evidence.

AGE OF THE *HANNATOMA* FAUNA

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The following paragraphs are comments on the age of the strata that contain the "*Hannatoma* fauna," and other strata related to them. They are based on several years of paleontological and field work in Ecuador and California and a single field trip in northern Peru in 1943. Most of the comparison of Peruvian mollusks with Californian forms was made with the advice and suggestions of Dr. A. M. Keen of Stanford University.

The "*Hannatoma* fauna" of the Punta Bravo grits includes *Hannatoma gesteri, H. tumbezi, Clementia peruviana,* etc. Equivalent or approximately equivalent zones in the same group of strata contain *Pitar wolfi, Sanguinolaria tumbezana, Macoma meroensis, Ampullinopsis spenceri,* etc. These species are found in both the Posorja and Zapotal beds of Ecuador. The Mancora formation at Mancora Narrows contains *Clementia peruviana, Macoma meroensis, Turritella consquitadorana,* etc. The stratigraphic position plus the species in common indubitably connect the Mancora and Punta Bravo beds, and the species in common link both to the Posorja and Zapotal strata of Ecuador.

A comparison of the apparently significant species found in the Mancora, Punta Bravo, Posorja and Zapotal (outcrop) beds with allied Californian forms furnishes basis for the following notes:

Anadara (*Scapharca*) *meroensis* (Olsson): no true *Anadara* is known from strata older than Oligocene throughout the world (Schenck and Reinhart 1938, p. 3).

Thyasira montanita Olsson: *Thyasira* is considered an Oligocene "marker" on the west coast of the United States, and is not recorded from strata older than Oligocene there.

Dosinia palmerae Olsson: true *Dosinia* is first known in California from the Vaqueros formation—disputedly Oligocene or early Miocene. The closest Eocene relative is *Dosiniopsis,* which is quite distinct.

Pitar, various species: forms similar to these are common in the California Eocene, but also continue to the Recent.

Turritella conquistadorana Hanna and

[6] Formerly with International Ecuadorean Petroleum Company.

Israelsky: in its tricostate nepionic whorls and later strong posterior flange this species resembles Merriam's *Turritella reversa* stock, which ranges from Paleocene to Middle Eocene. However, this same species is found in Lower Miocene strata in Ecuador with *Sconsia laevigata*, etc.

Pseudoliva sp. (an undescribed species from the Posorja outcrop in Ecuador): Tertiary *Pseudolivas* are known only from the Eocene in California. However, the type species is a Recent form from the African coast.

The molluscan species of Olsson's Mancora formation of the Chira and Lagunillas areas (Upper Eocene of Wiedey and Frizzell, 1939), have a decidedly Eocene cast. *Venericardia charanalensis, Surcula? mayi, Yasila chiraensis* and *Peruchilus culberti* are particularly significant and they are not associated with Miocene-appearing forms to counterbalance them. The appearance of *Ampullinopsis spenceri, Ampullina bravoensis* and *Hannatoma emendorferi* in the Mirador conglomerates of the Chira Valley indicate either that the part of the Mirador conglomerate in question is Oligocene, or that the three species range back to Eocene time. This problem is critical and I wish I were familiar with the stratigraphy of the Chira Valley so as to resolve it. The available literature seems to leave this question unanswered.

My conclusions resulting from this brief study are the following:

(1) The Punta Bravo grits with the "*Hannatoma* fauna," the Mancora, Posorja and type Zapotal strata occupy approximately the same stratigraphic position. They contain a molluscan assemblage that, from a California viewpoint, is strongly suggestive of Oligocene or younger age, but contains some elements of Eocene character. The evidence in favor of Oligocene age is stronger.

(2) At least some of Olsson's Mancora formation in the Chira Valley is Eocene according to the molluscan content. This conclusion confirms the statement of Wiedey and Frizzell (1939) and the inference of Cushman and Stone (1947).

(3) The stratigraphic position of the rocks containing *Ampullina bravoensis. Ampullinopsis spenceri* and *Hannatoma emendorferi* from the Mirador conglomerates of the Chira Valley region is important. If these rocks are truly Eocene, as appears probable from the age determinations, based on microfossils, of adjacent strata, the range of *Ampullinopsis spenceri* and the associated forms must be considered to extend back into Eocene time.

I have no personal acquaintance with the "*Hannatoma* fauna" of regions other than Ecuador and Peru. I have not seen sufficient published paleontological evidence to justify an undoubted age assignment of the various formations containing this fauna outside of Peru and Ecuador, especially where other evidence introduces a reasonable doubt. *Hannatoma* is apparently a brackish water genus that may well have existed since pre-Oligocene time. If *Ampullina bravoensis* and *Ampullinopsis spenceri* are Eocene in Peru, then the "critical" Oligocene species of the Carbonera formation are no longer critical.

The Zapotal formation of Ecuador is an accumulation of various types of marginal sediments around the rim of the incipient Progreso Basin graben. The surface sandstones at Zapotal contain mollusks which, as noted above, possess distinctly Oligocene features. An apparent anomaly results from the occurrence in the basin of subsurface shales with Eocene Foraminifera overlying sandstones with mollusks similar to Oligocene assemblages. This relationship may be attributed to the persistence of a certain facies, and it should be noted that no complete and self-determinative molluscan fauna has been described from a subsurface extension of the Zapotal formation underlying strata containing Eocene Foraminifera.

THE *HANNATOMA* FAUNA IN THE ZAPOTAL SANDS OF SOUTHWEST ECUADOR

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The age of the *Hannatoma* fauna in the Zapotal sands can be based either on long-range correlation of a minor fraction of the mollusc fauna or on a closely integrated foraminiferal zonation applicable to the whole Caribbean region. The writer considers the latter basis very much more satisfactory, and therefore strongly favours the Upper Eocene age determination deduced from it. It may prove that the *Hannatoma* fauna is facies-controlled and likely to occur in semi-brackish facies of both Eocene and Oligocene ages, but at least it is considered to be of proven Upper Eocene age in Ecuador by the standards currently accepted in the Caribbean region.

The mollusc assemblage commonly known as the *Hannatoma* fauna was described by A. A. Olsson (1931) conjointly from the Mancora sands of Peru and the Zapotal sands of Ecuador. The presence of *Ampullinopsis spenceri* Cooke and *Hemisinus* sp. aff. *H. antiguensis* Cooke was taken as evidence of correlation with the Middle Oligocene Antigua formation. In the field, the Zapotal sands were considered to be upfaulted with respect to contiguous Mambra (now termed Dos Bocas or Rodeo) shales, equivalent to the Upper Oligocene Heath shales of Peru.

Some ten years after Olsson published his opinions, the International Ecuadorean Petroleum Co. undertook detailed geological exploration in coastal Ecuador. Numerous wells were drilled in the Progreso Basin and foraminiferal zonation was applied to their correlation. It was discovered that between the Zapotal sands and the Upper Oligocene Rodeo shales there exists an extensive series, 3000 to 4000 feet thick, of shallow marine, brackish and terrestrial deposits. The marine shales in this section carry rich foraminiferal faunas with species such as *Bulimina jacksonensis*, *Hastigerinella eocenica* and (locally) *Hantkenina alabamensis*, which on a regional scale are regarded as Upper Eocene markers. Furthermore, within a few hundred feet of the top of this sequence there is a minor change in the faunas; the rigidly Eocene markers disappear, *Bulimina sculptilis* replaces *B. jacksonensis*, and the relative frequency of various *Globigerina* species changes. In a regional sense this faunal break corresponds to the Eo-Oligocene boundary. At the surface the Zapotal sands are in fault contact not with the Upper Oligocene Rodeo shales, as was once thought, but with the Lower Oligocene shales of the section just mentioned. This fault is one of the major graben-faults of the Progreso Basin, and its throw is sufficient to warrant direct correlation of the surface and subsurface sands which carry the *Hannatoma* fauna.

These Foraminifera-based findings, with their implication that the *Hannatoma* fauna occurs well below the top of the Eocene, flatly contradict Olsson's claim that this mollusc assemblage is Middle Oligocene. In the writer's opinion the foraminiferal evidence is much the more reliable. The Tertiary strata of coastal Ecuador carry rich microfaunas which have been studied in great detail at surface and in well sections. The Upper Eocene deposits vary in facies, but pelagic Foraminifera and Radiolaria can be used to confirm correlation across facies-province boundaries, thus giving a zonal scheme applicable along the whole extent of the coastal belt. On this basis the shallow marine to brackish shales overlying the Zapotal sands in the southwest are correlated unequivocably with the neritic Zapallo shales of the northwest. The Zapallo in turn carries a rich *Hantkenina*-bearing foraminiferal fauna comparable in detail with Upper Eocene faunas from western Colombia, the Tranquilla shale of Panama, the Amoura shale of Costa Rica, the Chapapote formation of Mexico, various Californian shales, the Gulf Coast Jacksonian, the San Fernando (Mount Moriah) silt of Trinidad, the Paují shale of Venezuela, etc. (for references see Stainforth, 1948). The Upper Eocene (Jackson) age of these units

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is agreed upon without notable exception by specialists in both megafossils and microfossils.

In the face of this convincing evidence of Upper Eocene age, the molluscs were determined as Middle Oligocene on the strength of only two species out of a list of nearly a hundred, the rest being described as new or indeterminate at the time the age assessment was made. Subsequent studies of the Zapotal molluscs by J. G. Marks and A. A. Olsson for International Ecuadorean Petroleum Co. have still further weakened the case for a Middle Oligocene age. The specific determination of *Ampullinopsis spenceri* was modified and in manuscript it was finally referred to a subspecies with affinities to the Vicksburg *A. mississippiensis* Conrad. The determination of *Hemisinus* sp. aff. *H. antiguensis* Cooke was left in this tentative form and never confirmed. Marks referred certain mollusc assemblages from wells to pre-Zapotal zones because of admixture of species previously only known in the Peruvian Eocene. In structural sections subsequently prepared by R. L. Milner these so-called "pre-Zapotal" faunas are seen to be no older, and in part definitely younger, than typical Zapotal assemblages with *Ampullinopsis spenceri*, etc. In other words the Zapotal mollusc faunas are locally intermingled with recognized Eocene forms.

In his original discussions Olsson drew support for an Oligocene age of the Zapotal sands from their inferential correlation with the Ancon Point and San Mateo sands on the coast. These latter carry cool-water marine molluscs of the *Acila-Thyasira-Pleurophopsis* suite, commonly regarded as Oligocene markers on the basis of studies in the California region. In Ecuador and Peru, however, these molluscs have been found within the life range of such Eocene markers as *Tubulostium* and *Hantkenina*.

The Zapotal sands and overlying beds mark the end of a cycle of sedimentary infill. The ensuing Rodeo shales are of marine origin indicative of subsidence and the commencement of a new cycle. In a single well in the centre of the Progreso Basin the basal Rodeo shales carried the late Middle to early Upper Oligocene 'Manta' fauna of marine Foraminifera. Around the margin of the basin there are remnants of *Miogypsina*-bearing reef-sands marking the initial phase of subsidence in the younger Oligocene. In northwest Ecuador a parallel subsidence is recognizable and its start is marked by strong marginal unconformities which dwindle away into the basin sediments. *Miogypsina* reefs occur at the base of the unconformable sediments. The time of the initial subsidence in the northwest fell between the extinction of *Globigerina* cf. *concinna* Reuss and *G. dissimilis* Cushman and Bermudez, i.e. at mid-Middle Oligocene. Assuming that subsidence was contemporaneous in the south, it is difficult to reconcile the presubsidence accumulation of up to 4000 feet of sediments above the Zapotal sands with the claim that these sands are Middle Oligocene.

The foregoing data are drawn, by permission, from various reports in the geological files of International Ecuadorean Petroleum Co. Much credit is due for detailed studies of megafossils to J. G. Marks and A. A. Olsson and of microfossils to F. V. Stevenson and H. E. Thalmann, all previously on the company's paleontological staff.

AGE OF THE CHIRA GROUP, NORTHWESTERN PERU

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The problem of the *Hannatoma* fauna in northwestern Peru concerns sediments known as the Chira group. These are the youngest Tertiary sediments which outcrop on the La Brea-Parinas Estate. In current usage the Chira group is divided into three lithologic units which are, from bottom to top, the Chira formation, Mirador formation and the Cone Hill formation. No satisfactory agreement has yet been reached between mollusc specialists and micropaleontologists on the age of these sediments. The

Chira group has been regarded as Oligocene in age because of the presence of *Hannatoma, Ampullinopsis* and *Pleurophopsis,* molluscs which are believed to be restricted to the Oligocene. Micropaleontologists, on the other hand, consider the Chira group to be Upper Eocene in age because of the presence of *Hantkenina, Stichocassidulina* and Upper Eocene species of *Bulimina, Hastigerinella* and other genera.

Cushman and Stone (1947) described the foraminiferal fauna of the Chira group and concluded that it could be no younger than Upper Eocene. This fauna ranges through the Chira group of sediments with little variation. The Mirador formation contains a microfauna essentially identical with that of the underlying Chira formation and although there is slightly more variation in the foraminiferal fauna of the overlying Cone Hill formation most of the species described from the Chira formation are still present.

Thalmann (1942) clearly established the value of the foraminiferal genus *Hantkenina* as an important Eocene marker. Howe (1928) reported *Hantkenina* from the Oligocene Red Bluff Clay, but in a personal communication (1946) has indicated that he now agrees with Thalmann and believes that his specimens from the lower Red Bluff Clay were reworked.

In northwestern Peru *Hantkenina* has been found only in the Chira group of sediments where it is represented by *H. alabamensis* Cushman. This species ranges from the middle of the Chira formation to the top of the overlying Mirador formation where it is most abundant. *Hantkenina* has not yet been found in the Cone Hill formation.

R. M. Stainforth (1948) has discussed the occurrence of *Bulimina jacksonensis* Cushman and *B. sculptilis* Cushman in the Eocene of Ecuador and other countries. *Bulimina jacksonensis* occurs chiefly in the, Eocene of North, Central and South America. Only very rarely has it been recorded from the Oligocene. *Bulimina sculptilis,* on the other hand, has been recorded mainly from the Oligocene of the same regions. Stainforth's records show that generally speaking *B. jacksonensis* may be regarded as a marker for the Upper Eocene and *B. sculptilis* for the Oligocene. In Ecuador there is a slight overlap of the ranges of these two forms. *Bulimina jacksonensis* continues (though rarely) into the basal Oligocene and *B. sculptilis* first appears very rarely in the Upper Eocene. A similar overlap of ranges is found in northwestern Peru where *B. jacksonensis* occurs abundantly throughout the Chira group with *B. sculptilis* occurring rarely and with slightly increasing frequency toward the top of the Cone Hill formation.

Stone (1946) described *Stichocassidulina thalmanni* from the basal Chira formation of Peru. It is now known that this species ranges upward into the Mirador formation, but is most abundant and best developed in the Chira shale. This species occurs in the Upper Eocene San Mateo formation of Central Ecuador and in the Upper Eocene Zapallo formation of northwestern Ecuador. It is also present but very rare in the Upper Eocene Kreyenhagen shale of California.

Mr. A. Martinez of the International Petroleum Company correlates the Seca formation (*Plectofrondicularia* zone) of the Engabao area of southwestern Ecuador with the upper Mirador formation. This correlation is based on a large number of species among which the following are the most important:

Bolivina maculata Cushman and Stone
Bulimina jacksonensis Cushman
Ellipsonodosaria spinosa (W. Berry) = *E.* sp. A. Cushman and Stone
Hantkenina alabamensis Cushman
Hastigerinella eocenica Nuttall
Pianulina peruviana Cushman and Stone
Plectofrondicularia peruviana Cushman and Stone
Robulus chiranus Cushman and Stone
R. fossilis Cushman and Stone
Stichocassidulina thalmanni Stone
Valvulineria chirana Cushman and Stone

Plectofrondicularia peruviana is the name species for the *Plectofrondicularia* zone in Ecuador. The correlation of this zone of the Seca formation and of the Upper Mirador formation is further substantiated by five species of the widespread pelagic genus *Globigerina* which occur in both formations. Underlying the *Plectofrondicularia* zone in the Engabao area of Ecuador is the *Stichocassidulina* zone which is characterized by an abundance of *S. thalmanni.* Although a detailed comparison of the pelagic fauna has

not been made of the *Stichocassidulina* zone zone it appears to be correlative with the Peruvian Chira formation.

The correlation of the Chira group with the Zapallo formation of Northwestern Ecuador is remarkable. Over sixty species of Foraminifera reported from the Chira formation are found in the Zapallo formation. Some of the more important species are:

Bolivina basisenta Cushman and Stone
Bolivina maculata Cushman and Stone
Bulimina chirana Cushman and Stone
Bulimina jacksonensis Cushman
Gumbelina venezuelana Nuttall
Hantkenina alabamensis Cushman
Hastigerinella eocenica Nuttall
Planulina peruviana Cushman and Stone
Plectofrondicularia peruviana Cushman and Stone
Robulus chiranus Cushman and Stone
Robulus coaledensis Detling
Stichocassidulina thalmanni Stone

Hantkenina alabamensis is very abundant in the Zapallo formation. In addition to the forms listed above Mr. A. Martinez (personal communication) has found that the Zapallo formation contains four species of *Globigerina* in common with the Mirador formation. On the basis of pelagic species the Chira formation is believed to be slightly older than the Zapallo formation of northwestern Ecuador. It is considered significant that mollusc specialists regard the molluscan fauna of the Zapallo formation as being Upper Eocene in age, although they consider the equivalent sediments in Peru to be Oligocene.

Dr. C. C. Church has very kindly supplied me with samples of the Upper Eocene Kreyenhagen shale of California which make possible a correlation of this formation with make possible a correlation of this formation with the Chira group in Peru. The following species occur in both the Kreyenhagen shale and the Chira group:

Bulimina chirana Cushman and Stone
Bulimina debilis Martin
Bulimina jacksonensis Cushman
Cibicides pseudoungerianus (Cushman)
Gyroidina soldanii d'Orbigny var. *octocamerata* Cushman and G. D. Hanna
Hantkenina alabamensis Cushman
Hastigerinella eocenica Nuttall
Pseudoglandulina turbinata Detling
Stichocassidulina thalmanni Stone

In addition to the above forms are *Valvulineria tumeyensis* Cushman and Simonson which is very close to *V. chirana* Cushman and Stone, and *Robulus welchi* Church, a form very closely related to or possibly identical with R. *chiranus* Cushman and Stone. Also present in the Kreyenhagen shale is a species of *Bolivina* which closely approaches *B. chirana* Cushman and Stone. The occurrence of *Stichocassidulina thalmanni* in the Kreyenhagen shale is particularly significant. To my knowledge this is the first occurrence of this important Upper Eocene genus in sediments outside of Peru and Ecuador.

The stratigraphic relationships of the Chira group are shown in table 1. In addition to the above correlations, the microfauna contains species which suggest some degree of correlation with the Upper Eocene sediments of Oregon and Washington in the United States, and with the Eocene of Mexico, Trinidad and Venezuela.

The Chira formation is essentially barren of megafossils. Occasionally a few species of *Cyrena, Polinices, Rimella* and *Turritella* have been found (Olsson, 1931). The overlying Mirador and Cone Hill formations, however, are relatively fossiliferous. The Mirador formation is the southern equivalent, in the Negritos area, of the Mancora formation from which the *Hannatoma* fauna was first reported in Peru. Olsson (1928) discusses the Mancora formation, in part. as follows:

> At its type locality, the Mancora formation has a thickness of 1,000 or 1,500 feet and is made up primarily of coarse, massive and well bedded sandstones, grits and conglomerates, with some chocolate shales. In places the color of the sands is rather brilliant and varicolored, including pure white, yellow, brown, red and green. The rocks are highly micaceous and on lithologic grounds resemble the variegated beds of the Zorritos Miocene and to a lesser degree the Cabo Blanco sandstones of the Middle Eocene. At Mancora, the fossils are mainly of marine origin.
>
> The Mancora rocks continue northward along the coast, gradually swinging inland toward the middle portion of the Tumbez river valley. They are particularly well developed from Punta Bravo northward to Punta Mero and inland crossing the Quebrada Boca Pan just north of Trigal. Along this line of outcrop, the rocks consist of brilliant white and varicolored grits, with interbedded conglomerates and red and green shales. These rocks are mainly of brackish-water origin and contain several species of brackish and fresh-water gastropods, such as *Pleurocera* and *Ampullinopsis*.
>
> South of Negritos, the Mancora rocks are ex-

posed also at Lagunitos, from which point they continue east and south throughout most of the Chira valley. At Lagunitos, the formation is largely gypsiferous shales with only minor beds of black cobble conglomerates. They contain the same fossils as the more typical beds to the north.

In the Chira valley, the Mancora rocks are generally rather sandy and conglomeratic, although the formation still shows considerable lateral variation. A very coarse conglomerate composed mainly of rather large black cobbles of igneous rocks occurs at Punta Mirador near the mouth of the Chira River. This conglomerate continues up the Chira valley and contains fossils similar to those found in the Punta Bravo grits.

In view of the fact that Olsson (1928) regarded *Pleurocera* and *Ampullinopsis* as brackish and fresh-water forms it seems likely that their associated genera may likewise prefer such ecologic conditions. If such is the case it appears reasonable to believe that these genera may be strongly facies

TABLE 1

STRATIGRAPHIC RELATIONS OF THE CHIRA GROUP, NORTHWESTERN PERU

		Northwestern Peru	Southwestern Ecuador	Central Ecuador	Northwestern Ecuador	California
UPPERMOST EOCENE	CHIRA GROUP	Cone Hill Formation			?	
		Mirador Formation	Seca Formation (*Plectofrondicularia*) zone)	San Mateo Formation	Zapallo Formation	Kreyenhagen Shale
		Chira Formation	Seca-Socorro Formation (*Stichocassidulina* zone)	?	?	

The more important megafossil genera of the Mirador formation are *Ampullinopsis*, *Hannatoma*, *Thyasira* and *Pseudoliva*. In the superjacent Cone Hill formation *Pleurophopsis*, *Thyasira* and *Acila* are present.

The occurrence in Peru of the *Hannatoma* fauna in the Upper Eocene is not unique. Some of the megafossil genera in question have been recorded in the Upper Eocene of other parts of the world. Davies (1934) writes as follows regarding the Nanggulan beds of Java, Netherlands East Indies:

> The Nanggulan fauna has been thoroughly studied by Prof. K. Martin of Leiden, who finds that no single species is European, but the genera are mainly Eocene genera characteristic of or even confined to the Eocene (or at least the older Tertiary). The exceptions are interesting, as they include genera not known in Europe, (nor N. America in most cases) before either the Oligocene (*Ampullinopsis*, *Chicoreus*, *Oniscidia*, *Merica*) or the Miocene (*Tectarium*, *Columbella*, *Nassa*, *Dorsanum*, *Mitrolumna*, *Trigonostoma*). *Nassa* and *Dorsanum* occur in the Upper Eocene of Peru.

controlled and their value as age indicating fossils may be questioned. Whatever the factors are that control the occurrence of the *Hannatoma* fauna, it is important to note that deeper water facies of the beds in which this fauna is found in Peru contain a typical Upper Eocene foraminiferal fauna consisting of *Hantkenina*, *Stichocassidulina* and species of other genera which correlate closely with the Upper Eocene foraminiferal faunas of other parts of North, Central and South America.

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ADDITIONAL CONODONTS FROM THE PENNSYLVANIAN OF IOWA

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ABSTRACT—Only a few conodonts have been previously described from the Pennsylvanian of Iowa. An additional collection has appreciably enlarged our knowledge of the fauna which was described in part in an earlier study. This more nearly complete assemblage is comparatively varied. Altogether, 13 genera, *Cavusgnathus, Drepanodus?, Euprioniodina, Gnathodus, Hindeodella, Idiognathodus, Ligonodina, Lonchodina, Metalonchodina, Ozarkodina, Prioniodus, Spathognathodus, Streptognathodus*, and 25 species are represented. The fauna is believed to be early Pennsylvanian in age.

FOLLOWING the discovery by Mr. C. B. Campbell of conodonts in the Pennsylvanian strata of south-central Iowa, Youngquist and Heezen (1948) published a short report on a few specimens collected during the fall of 1946.

Some time later, Mr. Campbell located a zone which yielded conodonts in much greater abundance than heretofore known in the Iowa Pennsylvanian. The locality is about ¾ mile northwest of Knoxville near the north section line of the NW¼ sec. 1, T. 75 N., R. 20 W., Marion County, Iowa, and is essentially the same as the first one (of two) which yielded the few conodonts of the previous report. The specimens occur here in a bed about 2 feet stratigraphically higher than the other, but less fossiliferous bed.

The fauna of the present report is relatively diversified (for a Pennsylvanian conodont assemblage) and is well preserved. Altogether some 700 specimens have been studied, and we are describing and illustrating the best of them.

As noted by C. L. Cooper (1947, p. 269), Pennsylvanian conodonts (particularly those of the lower portion of the system) have received but little study. Accordingly, the equivalents of the fauna under consideration are not readily determinable. Although it is not possible to point out many similarities with described species, the general aspect of this assemblage is more like that of the Cherokee shale (lower Des Moines) of Missouri than of any other described fauna.

Altogether the following conodonts are now known from the Pennsylvanian shales northwest of Knoxville. This summary includes the species described by Youngquist and Heezen, 1948, from essentially the same zone and locality as those of this study. Asterisks indicate forms occurring in the fauna of the present report):

**Cavusgnathus giganta* Gunnell
**Cavusgnathus? spicata* Youngquist and Downs, n. sp.
**Drepanodus?* sp.
**Euprioniodina pulcella* Youngquist and Downs, n. sp.
**Gnathodus websteri* Youngquist and Downs, n. sp.
Hibbardella subacoda (Gunnell)
**Hindeodella iowaensa* Youngquist and Downs, n. sp.
**Idiognathodus* cf. *I. acutus* Ellison
**Idiognathodus attenuatus* Youngquist and Heezen
**Idiognathodus bellatulus* Youngquist and Downs, n. sp.
Idiognathodus claviformis Gunnell
**Idiognathodus gomphus* Youngquist and Downs, n. sp.
**Idiognathodus iowaensis* Youngquist and Heezen (not described in present report)
**Idiognathodus mundulus* Youngquist and Downs, n. sp.
**Idiognathodus ornatus* Youngquist and Downs, n. sp.
**Idiognathodus rectus* Youngquist and Downs, n. sp.
Ligonodina? abbreviata Youngquist and Heezen
**Ligonodina* sp.
**Lonchodina unguicula* Youngquist and Downs, n. sp.
Lonchodus? sp.
Metalonchodina deflecta Youngquist and Heezen
**Metalonchodina* sp.
Ozarkodina campbelli Youngquist and Heezen
**Ozarkodina delicatula* (Stauffer and Plummer)
**Ozarkodina lauta* Youngquist and Downs, n. sp.
**Prioniodus cacti*, Gunnell
**Spathognathodus minutus* (Ellison)

Streptognathodus delicatulus Youngquist and Heezen
**Streptognathodus hastula* Youngquist and Downs, n. sp.
**Streptognathodus mucronatus* Youngquist and Downs, n. sp.
Streptognathodus symmetricus Youngquist and Heezen
**Streptognathodus tenuis* Youngquist and Downs, n. sp.
**Streptognathodus* sp.

Idiognathodus is the most abundantly represented genus in this assemblage. *Streptognathodus, Ozarkodina* and *Hindeodella* are also common. *Cavusgnathus, Drepanodus?, Euprioniodina, Gnathodus, Ligonodina, Lonchodina, Metalonchodina, Prioniodus* and *Spathognathodus* are comparatively rare. Among the many specimens available for study, there are no representatives of *Gondolella*. Ellison (1946, fig. 1) indicates that Gondolella is confined to post-Bend (that is, Des Moines and younger) strata. However, relatively few conodonts have been described from rocks of Bend age, and also inasmuch as conodonts are known to be facies fossils, the local absence of a particular genus is of questionable significance. Nevertheless, it is possible that the shale from which this assemblage was secured is pre-Des Moines in age.

Most of the specimens represent new species; the few previously described forms indicate that the containing beds are most probably equivalent to the Cherokee shale (lower Des Moines) of Missouri. However, the absence of *Gondolella* suggests that the shale may be pre-Des Moines in age.

Mr. C. B. Campbell of Knoxville, Iowa, has given us valuable field advice and assistance. In addition, he collected a large portion of the conodont fauna under consideration and generously donated these specimens to The State University of Iowa. Dr. H. Garland Hershey, State Geologist of Iowa, has given helpful information during the preparation of this report, as have Drs. A. K. Miller, Samuel P. Ellison, Jr. and W. H. Hass, and Mr. Bruce C. Heezen. All of the accompanying illustrations are photographs retouched by Mr. Howard Webster of Iowa City. The collection has been placed in the repository of the Geology Department at The State University of Iowa.

SYSTEMATIC PALEONTOLOGY

CAVUSGNATHUS GIGANTA GUNNELL
Plate 30, figures 18–20

Cavusgnathus gigantus GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 286, 287, pl. 33, figs. 7, 8.
Cavusgnathus gigantea GUNNELL, 1933, Jour. Paleontology, vol. 7, p. 264.
Cavusgnathus giganta ELLISON, 1941, Jour. Paleontology, vol. 15, pp. 108, 109, 110, 111, 126, pl. 21, figs. 44, 45, 49.
Cavusgnathus giganta ELLISON and GRAVES, 1941, Missouri Univ. Sch. Mines and Metall. Bull., tech. ser., vol. 14, no. 3, pp. 2, 4, pl. 3, fig. 3.
Cavusgnathus giganta ELLISON, 1944, *in* Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 325, pl. 45, figs. 44, 45, 49.

In nearly all details, the illustrated specimen is in close agreement with the holotype as well as with the other individuals which have been referred to this species. Our specimen appears to be complete and shows that the blade is relatively short.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa. Cooper (1947, p. 269) stated that "*Cavusgnathus giganta* apparently started in the Chester and lived on into the Permian."

Figured Specimen.—State Univ. Iowa, 14, 017.

CAVUSGNATHUS? SPICATA Youngquist and Downs, n. sp.
Plate 30, figures 24, 25

The generic affinities of this specimen are very uncertain. Both the oral and the lateral views of the platform (the only portion of the holotype preserved) show the pronouncedly spike-like nature of the oral surface. Superficially at least, this form is reminiscent of the genus *Cavusgnathus;* that is, there is a depressed central area which is bordered, particularly on the inner side, by a rather high, crenulate, and in part spiked parapet. The anterior portion of the plate shows a fractured surface which is indicative of the initial presence of a relatively large blade. No specimens are known to us that resemble this form to any appreciable degree.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,018.

DREPANODUS? sp.
Plate 30, figure 9

The illustrated individual is strikingly similar to representatives of the Ordovician genus *Drepanodus*, established by Pander. This specimen is a single cusp (with a slight suggestion of a very small denticle just anterior to the cusp) which is markedly compressed laterally, and a short distance orad from its base it is strongly curved in a direction assumed to be posterior. Clearly shown in transmitted light is a prominent internal structure which has been termed by some authors a "growth axis." It consists of light-colored cone-like structures which are lineally arranged in the cusp and which may be light-reflecting surfaces representing various growth stages of the specimen. These structures are more commonly found in conodonts from the Dutchtown and other early Paleozoic formations, but they are not rare in Pennsylvanian specimens.

Some of the syntypes of *Drepanodus subarcuatus* described by Furnish in 1938 from the Prairie du Chien beds of the Upper Mississippi Valley resemble the illustrated specimen (particularly Furnish's pl. 41, fig. 32). Direct comparison of Furnish's specimens with the Pennsylvanian form substantiates their similarity. This specimen would not be incongruous in an Ordovician conodont fauna. Possibly this is an example of "stratigraphic admixture," but, more likely one of homoeomorphy.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimen.—State Univ. Iowa, 14,019.

EUPRIONIODINA PULCELLA Youngquist and Downs, n. sp.
Plate 30, figure 6

This is a small form characterized by a short anticusp which bears 2 or 3 denticles, and a relatively short bar or blade which carries about 10 or 11 closely spaced, laterally compressed denticles. The cusp is not large, and is straight or essentially so in long axis. The bar is thin, and aborally attenuate, forming a small keel. Posteriorly, in lateral outline, the bar is bluntly and roundly terminated. The escutcheon beneath the cusp is very small. The figured specimen, the holotype, is complete except for the distal portions of the cusp and denticles.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,020.

GNATHODUS WEBSTERI Youngquist and Downs, n. sp.
Plate 31, figures 4, 5

Platform of holotype, in oral view, subovoal in outline. Carina is large, slightly sinuous, and persists the length of platform merging anteriorly with the blade. Oral ornamentation of platform, in addition to carina, consists of high, fine, transversely crenulate margins, separated from the carina by small depressed zones or sulci. Blade in lateral outline exhibits no well defined gradational series of denticles. However, in general, the denticles increase in size anteriorly to the largest which is located slightly anterior of the blade's midlength. Beyond this largest denticle, four or five smaller ones occur in diminishing magnitude. The entire aboral surface of the platform is occupied by a large escutcheon, which continues anteriorly a very short distance onto the blade. Aborally, the blade is moderately sharp, particularly in its anterior portion. It is terminated by nearly a right angle. The entire specimen is both gently bowed and arched.

This species is most nearly approximated by the form referred to *Gnathodus roundyi* and illustrated by Ellison (1941, pl. 23, figs. 27, 28, [misprinted as "28"]). However, our form differs in that it has a relatively larger platform which is broadly biconvex in oral outline, and has finely crenulate lateral platform margins. The carina on *G. websteri*, n. sp. extends posteriorly beyond the limits of one side of the platform proper but not the other side. *G. websteri* differs from the fragmental holotype of *Gnathodus roundyi* Gunnell in that the latter is hastate in oral platform outline. The blade of *G. roundyi* is essentially unknown.

Pander's original description of the genus *Gnathodus* did not establish it very precisely. Roundy (1926, p. 12) published an English translation of Pander's generic description, and subsequently referred several specimens to *Gnathodus*, commenting on the apparent abundant representation of that genus in

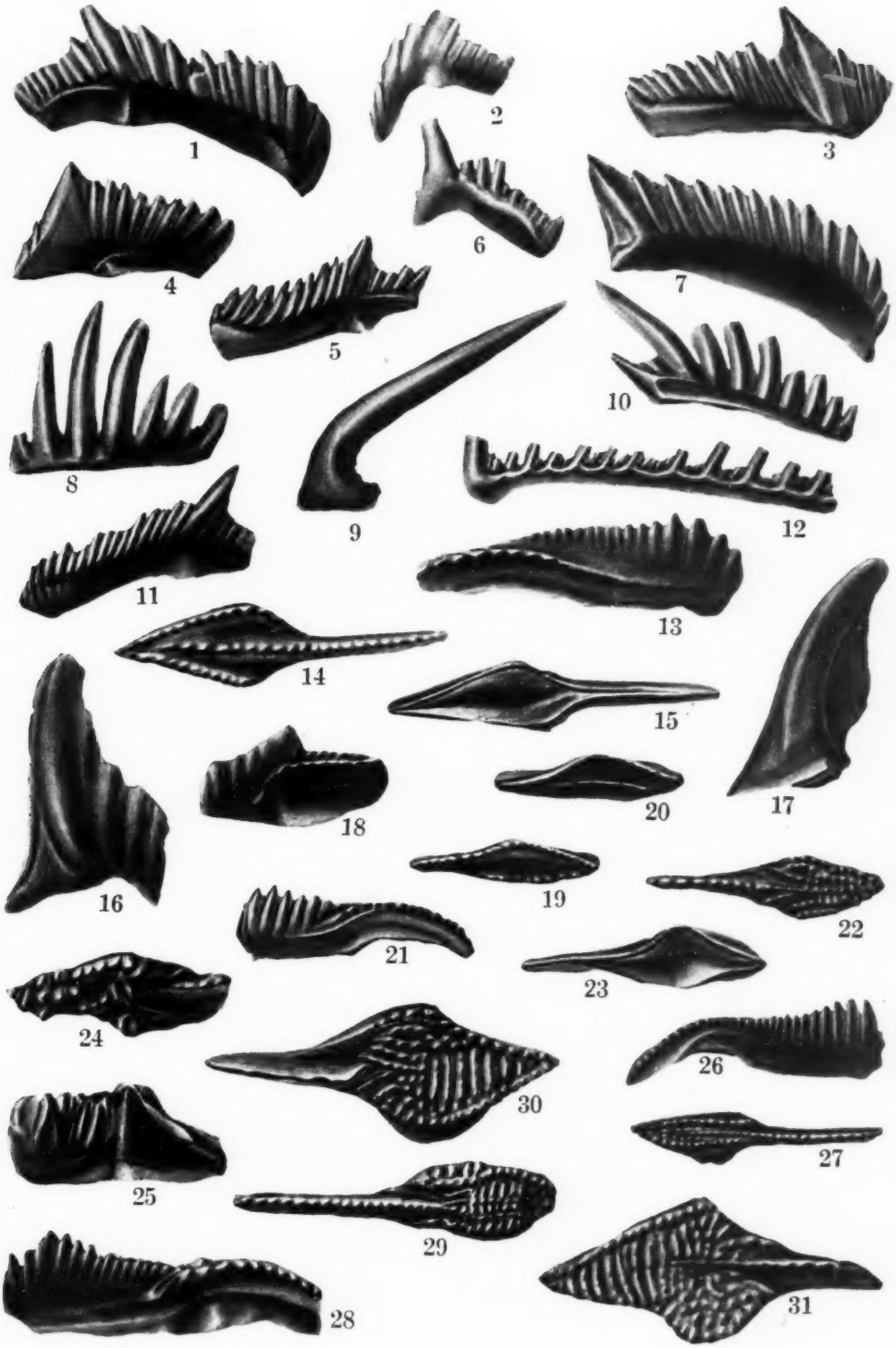
the Barnett shale of Texas. However, Ulrich and Bassler (1926, p. 54) stated that "after much speculation as to what *Gnathodus* may really be, we must admit failure to reach a satisfactory conclusion." Stauffer and Plummer in 1932, recognized the genus *Gnathodus*, and in the same publication established the genus *Streptognathodus*. They (1932, p. 47) stated that nodes usually occur on each side of the base of the platform of *Streptognathodus* and that the plate has "a deep axial furrow." Also, a carina (a posterior extension of the blade) "extends into the furrow and usually ends up at some point between the base [anterior end] and the middle of the plate." Their figure 27 of *S. elegantulus* on plate 2 shows this last feature. The specimen illustrated by their figure 13 on the same plate is referred to *Gnathodus* and it has a large carina extending the entire length of the plate. Ellison (1941, p. 127) discussed the characteristics of *Polygnathus*, *Streptognathodus*, *Idiognathodus*, and *Gnathodus* and stated that "*Gnathodus* differs from *Streptognathodus* in that the carina of the former is commonly prominent the full length of the platform and no accessory lobes are developed on the platform."

We too have given *Gnathodus* much consideration and have reached the following tentative conclusions: Pander's generic diagnosis leaves room for considerable latitude of interpretation. It seems to us that one of the more critical points in this original description is the reference to a row of "teeth" on the oral surface of the platform. Roundy (1926, p. 12) translated this as follows: "From a high, narrow, compressed base, constructed of double walls, arise in a row minute teeth, giving it the appearance of being bordered by a denticulate margin." Another translation of this same passage by Mr. Wladimer Ayvazoglou formerly of the U. S. Geological Survey, supplied to us by Dr. W. H. Hass, reads: "Small teeth rise in a row on a high, narrow plate consisting of double walls; an impression is given as if they are bordered by a dentated edge." Some of the numerous platform-type conodonts now available to us from the Pennsylvanian of Iowa do not fall within the limits of either *Idiognathodus*

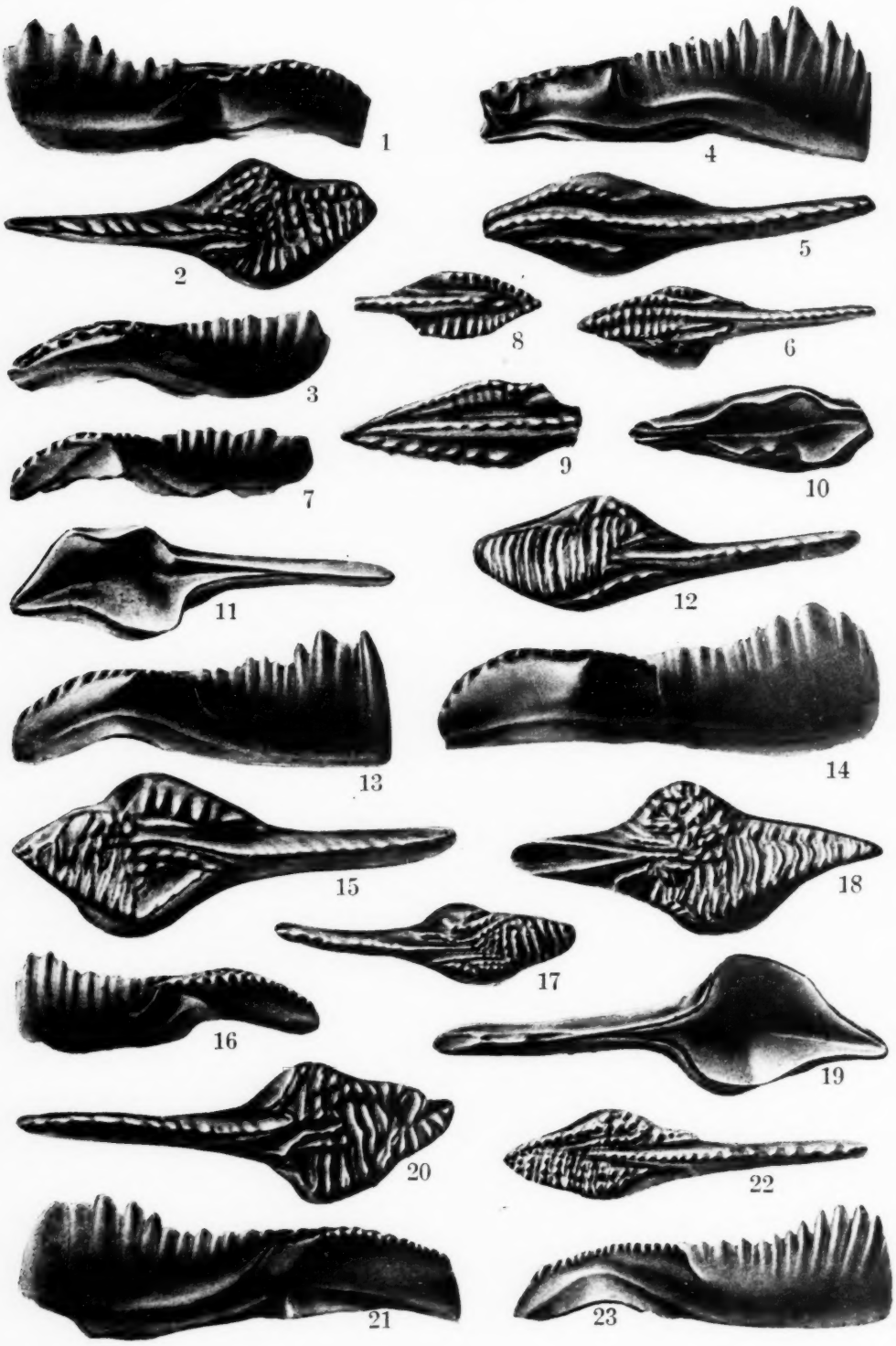
EXPLANATION OF PLATE 30

All specimens illustrated are from an early Pennsylvanian shale about ¾ mi. northwest of Knoxville, Iowa; and all figures are ×30.

FIG. *1—Ozarkodina delicatula* (Stauffer and Plummer). See also figures *3, 7, 11.* (p. 168)
2—Ligonodina sp. (p. 168)
3—Ozarkodina delicatula (Stauffer and Plummer). See also figures *1, 7, 11* (p. 168)
4—Spathognathodus minutus (Ellison) (p. 169)
5—Ozarkodina lauta Youngquist and Downs, n. sp. The holotype. (p. 169)
6—Euprioniodina pulcella Youngquist and Downs, n. sp. (p. 163)
7—Ozarkodina delicatula (Stauffer and Plummer). See also figures *1, 3, 11* (p. 168)
8—Lonchodina unguicula Youngquist and Downs, n. sp. Outer lateral view of the holotype. (p. 168)
9—Drepanodus? sp. (p. 163)
10—Metalonchodina sp. (p. 168)
11—Ozarkodina delicatula (Stauffer and Plummer). See also figures *1, 3, 7.* (p. 168)
12—Hindeodella iowaensa Youngquist and Downs, n. sp. The holotype. (p. 165)
13–15—Streptognathodus hastula Youngquist and Downs, n. sp. Three views of the holotype. (p. 170)
16, 17—Prioniodus cacti Gunnell. Outer and inner lateral views of two specimens. (p. 169)
18–20—Cavusgnathus giganta Gunnell. Inner lateral, oral, and aboral views of a single specimen. (p. 162)
21–23—Idiognathodus rectus Youngquist and Downs, n. sp. Three views of the holotype. (p. 167)
24, 25—Cavusgnathus? spicata Youngquist and Downs, n. sp. Oral and lateral views of the holotype (p. 162)
26, 27—Streptognathodus tenuis Youngquist and Downs, n. sp. Lateral and oral views of the holotype.
28, 29—Streptognathodus ornatus Youngquist and Downs, n. sp. Outer lateral, and oral views of the holotype (p. 170)
30, 31—Idiognathodus cf. *I. acutus* Ellison (p. 166)



Youngquist and Downs, Pennsylvanian Conodonts



Youngquist and Downs, Pennsylvanian Conodonts

or *Streptognathodus*. We are referring these to *Gnathodus* and interpreting the genus as follows: Posterior continuation of blade in the form of a carina is by far the most prominent feature of the oral surface of the platform and the most distinctive characteristic of the genus. This carina may be nodose or solidly ridge-like, but it persists the entire length of the platform and may extend posteriorly beyond the limits of the platform proper. Platform may have margins deflected orally, deflected aborally, or essentially horizontal. Some specimens may have the margins of one side of the platform deflected orally, the margins of the other side horizontal or deflected prominently aborally. Commonly the side with the aborally deflected margin is much smaller than the portion of the platform on the other side of the carina. The blade is usually much like that in either *Streptognathodus* or *Idiognathodus*, but it may be somewhat shorter and stouter. Aborally, the platform is broadly excavated just as in other genera of late Paleozoic platform-type conodonts (*e. g. Idiognathodus*, etc.) In lateral profile some representatives of *Gnathodus* (including Pander's specimens) cannot be distinguished with certainty from *Streptognathodus* or *Idiognathodus*. An oral view is usually essential to identifying *Gnathodus*,

We regard those forms in which the oral surface of the platform is predominantly trough-like as belonging in *Streptognathodus*, although a carina may persist down the center of the trough (as in figure 14 on our plate 30 and figures 8 and 9 on plate 31) but it does not extend beyond the limits of the platform proper.

This species is named in recognition of the work of Mr. Howard Webster of Iowa City, whose careful and accurate retouching of these and many other illustrations has greatly facilitated paleontological research at the State University of Iowa.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,048.

HINDEODELLA IOWAENSIS Youngquist and Downs, n. sp.
Plate 30, figure 12

Bar long, slender, very gently bowed and more strongly arched. Aboral side slightly grooved or flattened medianly; oral-lateral shoulder of bar somewhat sinuous from swellings at the places of the junction of the major denticles with the bar. In general, bar is rounded in cross section. Denticles occur in rather regular alternating series, that is, two to four minor denticles are intercalated between adjacent larger ones. Minor denticles are partially confluent with one another and therefore are not particu-

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EXPLANATION OF PLATE 31

All specimens illustrated are from an early Pennsylvanian shale about ¾ mi. northwest of Knoxville, Iowa; and all figures are ×30.

FIGS. *1–3—Idiognathodus bellatulus* Youngquist and Downs, n. sp. Two views of the holotype, and lateral view of a topotype. See also figs. *19–21*. (p. 166)

4, 5—Gnathodus websteri Youngquist and Downs, n. sp. Lateral and oral views of the holotype. (p. 163)

6, 7—Streptognathodus mucronatus Youngquist and Downs, n. sp. Lateral and oral views of the holotype. (p. 170)

8–10—Streptognathodus sp. Oral view of a small specimen; oral and aboral views of a more mature individual. (p. 170)

11–13—Idiognathodus iowaensis Youngquist and Heezen. Three views of a topotype. See also figs. *22, 23*. (p. 165)

14, 15—Idiognathodus gomphus Youngquist and Downs, n. sp. Lateral and oral views of the holotype. (p. 167)

16, 17—Idiognathodus mundulus Youngquist and Downs, n. sp. Two views of the holotype. (p. 167)

18—Idiognathodus attenuatus Youngquist and Heezen. Oral view of a topotype. (p. 166)

19–21—Idiognathodus bellatulus Youngquist and Downs, n. sp. Three views of the paratype. See also figs. *1–3*. (p. 166)

22, 23—Idiognathodus iowaensis Youngquist and Heezen. Two views of a topotype. See also figs. *11–13*. (p. 165)

larly rounded in cross section; major denticles are very round, and distally (as far as can be determined) incline inward. Cusp moderate in size, and has small aboral flange-like extension on outer (figured) side. Nature of bar anterior to cusp unknown, but presumably it was denticulate and short.

This form is perhaps closest to *H. diseriata* Stauffer and Plummer of the Mineral Wells formation of Texas. However, although a considerable length of bar is preserved, our specimen shows no indication of becoming "flattened and bladelike" posteriorly as is stated to be characteristic of the Texas form.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,021.

IDIOGNATHODUS cf. I. ACUTUS Ellison
Plate 30, figures 30, 31

?*Idiognathodus acutus* ELLISON, 1941, Jour. Paleontology, vol. 15, pp. 108, 111, 137, pl. 23, figs. 21, 24 [misprinted as "22, 25"].

?*Idiognathodus acutus* BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 325.

These two specimens which somewhat resemble *I. acutus* are incomplete anteriorly and we are uncertain as to their precise specific affinities. However, the platforms, which are preserved entire, resemble that structure of the paratype of this species rather closely. The blade of the specimen illustrated by our figure 30 appears to be somewhat unusual in that its oral edge slopes abruptly from the platform to its anterior aboral termination, is not in the least denticulate, and seems to be appreciably foreshortened. Presumably these features are the result of breaking or injuring of the blade during the life of the conodont-bearing animal. The blade is smoothly formed in its present condition and presents no rough or broken edges.

Occurrence.—Ellison stated that *I. acutus* is known from only the Des Moines and is particularly abundant in the upper Cherokee. Our specimens are from an early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimens.—State Univ. Iowa, 14,022 (fig. 30), 14,023 (fig. 31).

IDIOGNATHODUS ATTENUATUS Youngquist and Heezen
Plate 31, figure 18

Idiognathodus attenuatus YOUNGQUIST and HEEZEN, 1948, Jour. Paleontology, vol. 22, p. 769, pl. 118, fig. 5.

Only the platform of this large specimen is preserved. It is prominently elongate anterior-posteriorly, moderately expanded laterally on the inner (but not the outer) anterior portion, and is ornamented on its posterior oral surface by a number of transverse ridges. Aborally, the specimen is deeply and narrowly excavated. Direct comparison of this specimen with the essentially complete holotype of the species leaves little doubt that the two are conspecific.

Occurrence.—The holotype as well as our figured topotype are from early Pennsylvanian shales about ¾ mile northwest of Knoxville, Iowa.

Figured Specimen.—State Univ. Iowa, 14,024.

IDIOGNATHODUS BELLATULUS Youngquist and Downs, n. sp.
Plate 31, figures 1–3, 19–21

Platform prominently ornamented; posterior end more or less abruptly terminated, anterior portion laterally expanded, particularly on inner side. Oral ornamentation of posterior half of platform consists of about seven to nine large transverse ridges. Posteriorly, in the vicinity of the short carina, the platform is nodose. Aboral platform surface almost entirely occupied by broad escutcheon which continues in narrowed form slightly anterior onto the blade. About 9 or 10 denticles make up the blade which in lateral outline (see fig. 1) is slightly convex aborally and rounded anteriorly. Penultimate and antepenultimate denticles nearly equal in size and much larger than others. Platform gently arched and entire specimen very slightly bowed. The individual illustrated by figure 3, although superficially similar in lateral view to our *I. mucronatus*, n. sp., has a broad, stout platform and a relatively short blade. Probably this specimen can best be referred to *I. bellatulus*, n. sp., with which it was found in direct association.

A few of the specimens which have previously been referred to *I. claviformis* Gunnell are somewhat similar to our illustrated holotype of *I. bellatulus*. However, that specimen is in general stouter, and has a larger platform relative to the size of the blade than do the aforementioned individuals. In addition, the anterior aboral portion of the blade in our illustrated form is broadly rounded, whereas in *I. claviformis* the blade is abruptly terminated anteriorly by nearly a right angle (Ellison, 1941, pl. 23, fig. 17).

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimens.—State Univ. Iowa, 14,025 (holotype, figs. 1, 2), 14026, (paratype, fig. 3), 14,027 (paratype, figs. 19–21).

IDIOGNATHODUS GOMPHUS Youngquist and Downs, n. sp.
Plate 31, figures 14, 15

Total appearance of specimen in oral view, massive, club-shaped. Platform very large, broadly lozenge-shaped in outline, its greatest width is attained approximately at midlength. Orally, the platform is depressed in the anterior central portion relative to the crenulate edges. Posteriorly, there are several sinuous transverse ridges. Blade and platform subequal in length. Blade essentially straight, thick, composed of about 10 closely fused, stout denticles which attain greatest size in the antepenultimate denticle. In lateral outline the blade is convex aborally and rounded at its anterior termination. Aborally, the platform is broadly excavated; this escutcheon persists as a very narrow groove anteriorly for about half the length of the blade where it is gradually replaced by a sharp keel which persists along the remainder of the aboral blade margin. The club-like profile, and the large, massive nature of the specimen distinguish it from any other form known to us.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,028.

IDIOGNATHODUS MUNDULUS Youngquist and Downs, n. sp.
Plate 31, figures 16, 17

?*Idiognathodus* sp. BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, pl. 44, fig. 27.

Platform, in oral outline, narrowly ovoid. Blade and platform subequal in length; entire specimen slightly bowed and platform arched. About nine almost entirely confluent denticles constitute the blade which reaches its maximum height at the place of the ultimate or penultimate anterior denticle. Oral surface of platform bears four arcuate sulci, two on each side of the short carina which extends posteriorly from the blade onto the platform. Anterior margins of platform somewhat nodose; posterior half bears seven or eight transverse ridges. Aboral side of platform broadly excavated.

The particular specimen from the "Lower Pennsylvanian" illustrated by Branson (1944, pl. 44, fig. 27) as *Idiognathodus* sp., though slightly more attenuate, is similar to the individual figured here and the two may be conspecific. Though superficially resembling some of the specimens refered to *I. magnificus* Stauffer and Plummer, our specimen does not resemble the syntypes of that species.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa. Possibly occurs also in the Lower Pennsylvanian of Missouri.

Holotype.—State Univ. Iowa, 14,032.

IDIOGNATHODUS RECTUS Youngquist and Downs, n. sp.
Plate 30, figures 21–23

Platform and blade, in plan view, exceptionally straight. Platform narrowly oval in oral outline, half again as long as the blade, and ornamented on its posterior surface with about seven or eight small transverse ridges. Anterior portion of platform is laterally nodose and medially (in the vicinity of the short carina) bears small arcuate sulci. Blade composed of about eight denticles which are more or less gradational in size, the largest being anterior (except for a very small ultimate denticle). Aboral third of blade thickened toward the platform. Platform gently arched in profile.

This species is somewhat similar to *I. tersus* Ellison, but differs in the smaller number of denticles composing the blade, and the relatively greater length of the platform. Also, in *I. tersus* the carina and the sulci "end abruptly" posteriorly against the first transverse ridge. The transverse ridges on *I. rectus* are not well developed and the posterior trend of the carina persists the entire length of the platform, anteriorly as a small ridge, and posteriorly as a slight groove.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,033.

LIGONODINA sp.
Plate 30, figure 2

This specimen, though incomplete, retains features sufficiently diagnostic to determine its generic affinities with reasonable certainty. The relatively large, denticulate laterally deflected anticusp, and the size, shape, and inclination of the cusp and posterior denticles are reminiscent of *Ligonodina*. The rather thin, blade-like character of this form is, however, somewhat unusual for the genus. No closely similar forms are known.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimen.—State Univ. Iowa. 14,035.

LONCHODINA UNGUICULA Youngquist and Downs, n. sp.
Plate 30, figure 8

Entire specimen moderately bowed, but not appreciably arched. The figured specimen, which appears to be essentially complete, has about eight denticles. At and near the extremities of the bar they are short, stout and rounded in cross section; the three denticles located at mid-length or slightly anterior on the bar are very large, compressed laterally, sharpened anteriorly and posteriorly, and curve inward as well as slightly backward. Aboral surface of bar slightly convex aborally and bears small median ridge. Bar swells laterally, attaining maximum thickness near its midlength.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,036.

METALONCHODINA sp.
Plate 30, figure 10

Although the bar decreases in size toward the right (presumably posterior) end of the specimen, the denticles incline in the opposite direction (presumably anterior). The figured specimen is fragmentary, but if the foregoing characters are correctly interpreted, there can be no doubt as to its generic affinities.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimen.—State Univ. Iowa, 14,037.

OZARKODINA DELICATULA (Stauffer and Plummer)
Plate 30, figs. 1, 3, 7, 11

Bryantodus delicatulus STAUFFER and PLUMMER, 1932, Texas Univ. Bull., no. 3201, pp. 25, 29, pl. 2, fig. 27.

Bryantodus nasutus STAUFFER and PLUMMER, 1932, Texas Univ. Bull., no. 3201, pp. 25, 29, pl. 2, fig. 28.

Bryantodus sulcatus STAUFFER and PLUMMER, 1932, Texas Univ. Bull., no. 3201, pp. 25, 30, pl. 2, figs. 11, 14, 30.

Bryantodus delicatus GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 264, 267–269, pl. 32, fig. 43.

Bryantodus rugosus GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 264, 268, pl. 32, fig. 44.

Bryantodus strigatus GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 264, 268, pl. 32, fig. 45.

Bryantodus strigillatus GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 264, 268, pl. 32, fig. 46.

Ozarkodina delicatula ELLISON, 1941, Jour. Paleontology, vol. 15, pp. 108, 109, 110, 111, 120, pl. 20, figs. 40–42, 47.

Ozarkodina delicatula ELLISON and GRAVES, 1941, Missouri Univ. Sch. Mines and Metall. Bull., tech. ser., vol. 14, no. 3, pp. 3, 4, pl. 1, figs. 12–14.

Ozarkodina delicatula BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 327.

The genus *Ozarkodina*, as now generally interpreted, is well represented in the collection under consideration. We illustrate four fragmentary specimens which appear to be referable to *O. delicatula*. Our best specimen (fig. 1) retains all of the anterior limb and much of the posterior one. It is rather strongly arched and gently bowed. Twelve laterally compressed, partially confluent denticles are preserved anterior to the cusp. All denticles, as well as the cusp, are moderately curved posteriorly and slightly inclined inward. The cusp is small. The escutcheon

which is beneath the cusp is not particularly large and is encompassed by flange-like extensions of the aboral margin of the blade. A well developed keel is present on the anterior portion of the blade. The posterior aboral development of the specimen is uncertain, but presumably was likewise prominently keeled. The other specimens being referred to this broadly interpreted species do not seem to differ significantly from forms which have been previously regarded as conspecific.

The genus *Ozarkodina*, as it is now distinguished, ranges from Lower Ordovician to Lower Permian. It seems improbable that a single generic form can be correctly regarded as having such a long stratigraphic range. The genus *Bryantodina* of the Middle Ordovician and *Bryantodus* of the Devonian and Mississippian appear in some instances to be gradational with specimens of *Ozarkodina* found in the same or essentially contemporaneous beds. Also, the species *O. delicatula*, as now delimited, ranges from the early Pennsylvanian Cherokee shale to the Lower Permian Big Blue series. Additional material may show that the several forms now included in *O. delicatula* can be zoned to some extent and a refinement of the present classification may be both practical and desirable.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa. Also widely reported from rocks ranging in age from Lower Pennsylvanian to Lower Permian.

Figured Specimens.—State Univ. Iowa, 14,038 (fig. 1), 14,039 (fig. 3), 14,040 (fig. 7) 14,041 (fig. 11).

OZARKODINA LAUTA Youngquist and Downs, n. sp.
Plate 30, figure 5

Although found in direct association with *O. delicatula*, the possession of only about eight denticles on the anterior bar limb rather than "12 or more" (Ellison, 1941, p. 120) differentiates *O. lauta* from that species. In addition, the anterior limb is somewhat convex aborally, that is, the aboral margin curves orally in the vicinity of the cusp and near its anterior end. The cusp is small, but the escutcheon is well developed and the outer aboral margin of the bar flares strongly. The posterior limb of the figured specimen is incomplete.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,042.

PRIONIODUS CACTI Gunnell
Plate 30, figures 16, 17

Prioniodus cacti GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 263, 265, 267, pl. 31, figs. 4, 5.
Prioniodus sp. GUNNELL, 1933, Jour. Paleontology, vol. 7, pp. 264, 267, pl. 32, fig. 32.
Prioniodus conjunctus [part], ELLISON, 1941, Jour. Paleontology, vol. 15, pp. 108, 109, 110, 111, 113–114, pl. 20, figs. 1–3, 16.
Prioniodus conjunctus, [part], GUNNELL, 1944, *in* Branson, Missouri Univ. Studies, vol. 19, no. 3, p. 327.

These specimens are representative of a generalized type of *Prioniodus* which has a long range in the Paleozoic. They can be compared with other individuals having confluent denticles and a laterally compressed cusp, such as *P. alatus* Hinde which is widely distributed in the Devonian and early Mississippian. Our best specimen (fig. 16) has a rather stout, laterally compressed cusp which is broadly flared on its inner (unfigured) aboral margin (see fig. 17—inner view of similar specimen). The anticusp is small and projects anteriorly as well as aborally, but is not appreciably deflected laterally. The holotype of *P. conjunctus* Gunnell (1931) is so incomplete as to make comparisons with that form very uncertain. Specimens from the fauna described here appear to be referable to *P. cacti* Gunnell from the Cherokee of Missouri, and may also be conspecific with the forms described by Ellison (1941) and referred to *P. conjunctus*.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimens.—State Univ. Iowa, 14,043 (fig. 16) 14,044 (fig. 17).

SPATHOGNATHODUS MINUTUS (Ellison)
Plate 30, figure 4

Spathodus minutus ELLISON, 1941, Jour. Paleontology, vol. 15, pp. 108–111, 120, pl. 20, figs. 50–52.
Spathognathodus minutis ELLISON and GRAVES, 1941, Missouri Univ. Sch. Mines and Metall. Bull., tech. ser., vol. 14, no. 3, p. 3.
Spathognathodus minutus ELLISON and GRAVES,

1941, Missouri Univ. Sch. Mines and Metall. Bull., tech. ser., vol. 14, no. 3, pp. 3, 4, pl. 2, figs. 1, 3, 5.

Spathodus minutus BRANSON, 1944, Missouri Univ. Studies, vol. 19, no. 3, p. 327.

As pointed out by Ellison (1941, p. 120), representatives of the genus *Spathognathodus* are rare in Pennsylvanian strata. Our collection includes only a single specimen referable to that genus. However, it is exceptionally well preserved and is strikingly similar to the holotype of *S. minutus*.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa. Reported to occur in beds ranging in age from the Cherokee shale to the Big Blue series.

Figured Specimen.—State Univ. Iowa, 14,045.

STREPTOGNATHODUS HASTULA Youngquist and Downs, n. sp.
Plate 30, figures 13–15

Holotype spear-shaped in oral outline. Platform longer than blade, symmetrical, pointed posteriorly. Oral margins of platform crenulated, median carina prominent in vicinity of blade, but more or less discontinuous and node-like posteriorly. Areas between carina and platform margins are depressed. Aborally, the margins of the platform are not appreciably flared laterally or thickened, the escutcheon being essentially the same size as the oral surface. Blade composed of about 15 denticles which reach maximum development slightly anterior of the blade's midlength.

This species appears to be related to the incomplete specimens we are illustrating as *Streptognathodus* sp. (pl. 31, figs. 8–10) but differs from them in the lesser development of the carina and adjacent depressed platform areas, and also the nature of the escutcheon development is quite different (cf. pl. 30, fig. 15 with pl. 31, fig. 10).

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,046.

STREPTOGNATHODUS MUCRONATUS
Youngquist and Downs, n. sp.
Plate 31, figures 6, 7

Platform long, narrow, rather symmetrical. Oral surface of posterior half transversely ornamented by small, partially fused nodes. Oral ornamentation subdued. Anterior part of platform bears a small carina and on each side of it, small sulci. Blade and platform essentially straight in long axis. Eight to ten denticles compose the blade which in lateral profile is rounded anteriorly. Aborally, the platform is narrowly excavated and the blade is sharpened. Platform is somewhat longer than the blade, and moderately arched.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,031.

STREPTOGNATHODUS ORNATUS
Youngquist and Downs, n. sp.
Plate 30, figures 28, 29

Platform suboval in oral outline, about equal in length to the blade, intricately ornamented. Oral margins of posterior portion of platform bear single rows of discrete nodes; anterior inner oral margin is slightly expanded laterally and bears two short rows of nodes. Median area of platform bears about six or seven short transverse ridges which do not extend to the platform margins. A slight trace of the carina persists almost the entire length of the platform and anteriorly merges with the blade. Two small arcuate sulci occur on each side of the anterior portion of the carina. The blade is essentially straight, thin and consists of about 15 or 16 denticles which increase progressively in size anteriorly and attain maximum size at the place of the third or fourth denticle posterior to the blade's termination. Aboral margin of blade sharpened and relatively straight. Platform is slightly arched. The median zone of transverse rugae, which does not persist to the platform margins, is perhaps the most distinctive feature of this species.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Holotype.—State Univ. Iowa, 14,047.

STREPTOGNATHODUS sp.
Plate 31, figures 8–10

Two fragmentary specimens in our collection have prominently depressed oral platform surfaces. This elongate trough is medianly divided by a rather large carina

which persists the greater length of the platform, becoming indistinct posteriorly. In oral outline, the platform is almost bilaterally symmetrical and lanceolate; the lateral margins are transversely rugose. The aboral platform surface (fig. 10) is only partially occupied by an escutcheon which attains its greatest size anteriorly and is abruptly narrowed in its posterior third. The specimen illustrated by figure 8 (though probably immature) appears to be conspecific with that illustrated by figures 9 and 10.

Branson (1944, pl. 44, fig. 40) illustrated a specimen from the "Lower Pennsylvanian" of Missouri and designated it *Streptognathodus* sp. Ellison and Graves illustrated a somewhat similar form (1941, pl. 2, fig. 14) from the Dimple limestone of Texas, referring it to the genus *Gnathodus*, and identifying it with the species originally described by Harlton (1933, p. 15, pl. 4, figs. 13 a–c) as *Polygnathus wapanuckensis*. These two specimens and the forms illustrated here are, in oral view at least, strikingly similar.

Occurrence.—Early Pennsylvanian shale about ¾ mile northwest of Knoxville, Iowa.

Figured Specimens.—State Univ. Iowa, 14,049 (fig. 8), 14,050 (figs. 9, 10).

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EARLY TERTIARY OSTRACODA FROM THE WESTERN INTERIOR UNITED STATES

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ABSTRACT—Ostracodes from the Paleocene Fort Union formation, the Paleocene or Eocene Flagstaff limestone, and the Eocene Colton, Wasatch, Knight, and Green River formations of Wyoming, Montana, Utah, and Colorado are described. Two small collections from the Paleocene Fort Union formation and Cannonball formation of North Dakcta are recorded. All of the forms, except those from the Cannonball, are nonmarine and mostly suggest a lacustrine environment.

Ilyocypris arvadensis tuberculata Swain, n. var., was observed only in the Tongue River member of the Fort Union formation. *I. arvadensis* Swain, n. sp., perhaps is restricted to the Paleocene and to the Eocene of pre-Green River age. *Cyprois* cf. *C. marginata* (Strauss) and *Erpetocypris?* sp. are rare in the upper part of the Paleocene and are more characteristic of the Eocene of this region. The five species recorded from the Cannonball formation are similar to or identical with forms in the Midway group of the Gulf region.

Cypridea Bosquet has not been previously reported from Cenozoic rocks in North America. *C. punctata* (Forbes), selected as genotype by F. W. Anderson, apparently cannot be so used, as at least seven other species have priority over it. Of these, *C. granulosa* (Sowerby) is suggested as the genotype.

Erpetocypris Brady and Norman (1889) involves an error in transliteration, but the original orthography should be preserved, and *Herpetocypris* Sars (1890), although recognized by Brady and Norman in 1896, should be suppressed.

INTRODUCTION

THE continental early Tertiary deposits of the western interior United States locally contain abundant cyprid ostracodes. Several collections of these fossils have been made available for study during the past few years by the U. S. Geological Survey and by Raymond E. Peck, of the University of Missouri. Another lot of samples considered here was submitted to C. R. Stauffer in 1924 by C. E. Erdmann.

In a previous paper the writer (Swain, 1947) described several forms from the later Tertiary of Utah, and pointed out the essentially modern character of that faunule. None of the unique forms, such as *Tuberocypris* and *Tuberocyproides* of the later Tertiary, have been observed in the material at hand, and all of the simpler species are specifically different at the two stratigraphic levels. Facies variations evidently control the presence or absence of the ostracodes both in the early and late Tertiary, but, in a general way, where these ostracodes occur in moderate or great abundance, a lacustrine environment is indicated.

A list of the localities from which the specimens were obtained follows:

(1) Paleocene, Fort Union formation, Tongue River member, NW¼ sec. 31, T. 9 S., R. 49 E., Moorhead coal district, Powder River County, Mont., 125 feet above Anderson coal, collected by R. P. Bryson: *Candona* sp., *Darwinula* cf. *D. stevensoni* Brady and Robertson.

(2) Paleocene, Fort Union formation, Tongue River member, NW¼ sec. 31, T. 9 S., R. 49 E., Powder River County, Mont., collected by R. P. Bryson (presumably at a different stratigraphic level from preceding): *Ilyocpris arvadensis* Swain, n. sp.

(3) Paleocene, Fort Union formation, upper part of Tongue River member, SW¼ SE¼ SW¼ sec. 17, T. 9 S., R. 45 E., Powder River County, Mont., collected by W. H. Hass: *Candona pagei* Swain, n. sp., *Ilyocypris arvadensis* Swain, n. sp.

(4) Paleocene, Fort Union formation, Tongue River member, NE¼ sec. 18, T. 142 N., R. 90 W. Knife River area, N. Dak., collected by W. E. Benson: *Candona* sp., *Limnicythere* sp.

(5) Paleocene, Cannonball formation, Sawyer Quadrangle, SW¼ sec. 12, T. 153 N., R. 81 W., 1½ miles east of Sawyer, N. Dak., collected by R. W. Lemke: *Cytheridea* cf. *C. multipunctata* Alexander, *C. ruginosa* Alexander, *C.* cf. *C. fornicata* Alexander, *Cythereis* cf. *C. prestwichiana* Jones, *Brachycythere* cf. *B. interrasilis* Alexander.

(6) Paleocene, roof of Roland coal, SE¼ sec. 13, T. 9 S., R. 45 E., Powder River County, Mont., collected by W. H. Hass: *Erpetocypris?* sp., *Ilyocypris arvadensis* Swain, n. sp., *I. arvadensis tuberculata* Swain, n. var.

(7) Paleocene or Eocene, Flagstaff limestone, 1 mile west of Ephriam, Utah, sampled by R. E. Peck, starting at base of the Flagstaff on a very finely crystalline, massive, 2-foot ledge of limestone and extending up for about 50 feet: *Erpetocypris?* sp., *Cyprois* cf. *C. marginata* (Strauss), *Ilyocypris arvadensis* Swain, n. sp.

(8) Sample taken above the preceding, in lower 50 feet of Flagstaff limestone: *Erpetocypris?* sp., *Cyprois* cf. *C. marginata* (Strauss), *Cypridea bisulcata* Swain, n. sp.

(9) Sample taken above the preceding, in lower 50 feet of Flagstaff limestone: same as No. 8.

(10) Sample taken above the preceding, in lower 50 feet of Flagstaff limestone: *Candona pagei* Swain, n. sp., *Cypridea bisulcata* Swain, n. sp.

(11) Eocene, Colton formation, 8 miles north of Castlegate, Utah, on Highway 33, sampled by R. E. Peck above a very fossiliferous mudstone: *Cypridea bisulcata* Swain, n. sp.

(12) Sample taken above the preceding: *Cypridea bisulcata* Swain, n. sp.

(13) Sample taken above the preceding: *Candona pagei* Swain, n. sp, *Ilyocypris arvadensis* Swain, n. sp.

(14) Basal Eocene, Wasatch formation; 4½ miles east of Arvada, Wyo., NW¼ SW¼ SW¼ sec. 6, T. 54 N., R. 76 W., Mont., between Arvada and Roland coals, collected by V. W. Russom: *Ilyocypris arvadensis* Swain, n. sp.

(15) Eocene, Wasatch formation, basal part; sec. 6, T. 54 N., R. 76 W., Sheridan County, Wyo., collected by V. W. Russom: *Ilyocypris arvadensis* Swain, n. sp.

(16) Lower Eocene; general locality secs. 3, 4, 9, 10, T. 14 S., R. 14 E., near Sunnyside, Carbon County, Utah, collected by B. M. Page: *Candona pagei* Swain, n. sp., *Erpetocypris?* sp., *Cyprois* cf. *C. marginata* (Strauss).

(17) Eocene, Knight formation; 20 miles east of Evanston, Wyo., sampled by R. E. Peck near a calcareous white sandstone bearing ostracodes, about 80 feet below limestone capping a hill on the north side of U. S. Highway 30, near contact with Green River formation: *Candona pagei* Swain, n. sp., *Cyprois* cf. *C. marginata* (Strauss).

(18) Eocene, Green River formation; 11 miles north of Castlegate, Utah, sampled by R. E. Peck near a fossiliferous limestone, about 30 feet below a thin fossiliferous limestone in lower part of Green River formation: *Erpetocypris?* sp.

(19) Same locality as preceding, sampled above and below a fossiliferous impure limestone, slightly above highest red sand of the exposure: *Erpetocypris?* sp., *Scottia?* sp. aff. *S. browniana* (Jones).

(20) Eocene, Green River formation, fresh-water ostracode limestone; sec. 4, T. 2 N., R. 94 W., Colo., collected by C. E. Erdmann: *Erpetocypris?* sp.

(21) Eocene, Green River formation, thin-bedded ostracode limestone, "frequently intercalated with gray sandy shales. The latter often have many ostracodes upon their bedding planes." 1½ miles north of L. A. Nick's ranch house, Scenery Gulch, 20 miles west of Meeker, Col., down the White River, collected by C. E. Erdmann: *Erpetocypris?* sp.

(22) Eocene, Green River formation, about 100 feet above base; sampled by C. E. Erdmann in a shaly part of a mostly massive sandstone containing "countless ostracodes": *Candona pagei* Swain, n. sp., *Cyprois* cf. *C. marginata* (Strauss), *Cypridea bisulcata* Swain, n. sp.

(23) Eocene, Green River formation; Gray Hills, west of Strawberry Creek, 12 miles northwest of Meeker, Colo., pisolitic-oolitic limestone, sampled by C. E. Erdmann: *Erpetocypris?* sp.

(24) Eocene(?); SW¼ sec. 16, T. 1 S., R. 7 W., Uinta Special Base Line, 2.2 miles NNE of Tabiona, Utah, collected by J. W. Huddle: *Candona pagei* Swain, n. sp.

(25) Eocene, probably, Knight forma-

tion; 6 miles east of Kemmerer, Wyo., on north side of U. S. Highway 30, sampled by R. E. Peck in a greenish, fossiliferous, calcareous sand and shale: *Candona pagei* Swain, n. sp., *Cypridea bisulcata* Swain, n. sp.

It is not possible to arrive at a satisfactory conclusion regarding the stratigraphic value of these ostracodes at the present time, although it seems likely that additional study will demonstrate their usefulness. Upper Cretaceous and middle Tertiary nonmarine ostracodes from the region are not well known and should be investigated further. The early Tertiary forms are obviously so different from those in the late Cretaceous and late Tertiary of the western interior region that a zonal relationship appears to be a good possibility. Our present knowledge of these nonmarine forms may be compared to that of the European geologists about 100 years ago with respect to the now stratigraphically important late Jurassic and early Cretaceous nonmarine ostracodes.

The complex facies relationships in the Upper Cretaceous, Paleocene and Eocene of the area, which results in the partial equivalence of many of the named units, makes the ranges of the ostracodes uncertain. The few tentative suggestions offered below are subject to modification when additional data have been accumulated.

The tuberculate variety of *Ilyocypris arvadensis*, n. sp., although rare, was observed only in the Paleocene Fort Union formation (locality 6).

Erpetocypris? sp. of this paper evidently is rather characteristic of the Eocene, but occurs locally in the upper part of the Paleocene (locality 6). It is very abundant locally in the Green River formation in Colorado (localities 20, 21).

Cyprois cf. *C. marginata* (Strauss) was not found in strata definitely of Paleocene age, unless the lower part of the Flagstaff limestone in central Utah belongs in that epoch (locality 7). *Cypridea bisulcata*, n. sp. appears abundantly in a sample above the base of the Flagstaff at locality 8 where it supersedes *Ilyocypris arvadensis*, n. sp. An environmental change is indicated by this replacement, and it is possible that the Paleocene-Eocene boundary at that locality lies in the lowermost part of the Flagstaff.

Ilyocypris arvadensis, n. sp. is abundant in the Paleocene (localities 2, 3, 6) and in the lower part of the Eocene (localities 13, 14, 15), but was not found in any of the samples from the Green River formation.

All of the species obtained from the Cannonball formation (locality 5) occur in the Paleocene Midway group of Texas. *Cytheridea fornicata* Alexander occurs in the lower Midway Kincaid formation, and *C. multipunctata* occurs in the upper Midway Wills Point formation in Texas. The other species range throughout the Midway, but are restricted to it, and the faunule as a whole supports the conclusions of Fox and Ross (1942) as to the Paleocene age of the Cannonball.

Appreciation is expressed to J. B. Reeside, Jr., who made available the ostracodes collected by W. E. Benson, R. P. Bryson, W. H. Hass, J. W. Huddle, R. W. Lemke, B. M. Page, and V. W. Russom, and supplied information about the stratigraphy of the region; to R. E. Peck who furnished several important collections of ostracodes; and to C. R. Stauffer who allowed the writer to make use of material sent to him in 1924 by C. E. Erdmann. L. E. Monley assisted in the preparatory and photographic work. The study was supported by the U. S. Geological Survey, and the type specimens are deposited in the U. S. National Museum.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille
Family CYPRIDAE Baird, 1846
Subfamily CYPRINAE Sars, 1928
Genus CANDONA Baird, 1850

CANDONA PAGEI Swain, n. sp.

Plate 32, figures 1–4, 6, 7

Shell subovate-reniform in side view; highest at or just anterior to midlength; dorsal margin gently convex; ventral margin sinuous, concave submedially; anterior margin broadly rounded; posterior margin more narrowly rounded, slightly extended submedially and truncate above in right valve. Left valve slightly overlaps right, but is not appreciably larger; free edges of valves inconspicuously rabbeted. As seen in edge view, shell tumid, most convex medially, slightly thicker in posterior portion. Surface

minutely ornamented with extremely fine pits; interspaces equal to about half or two thirds diameter of pits; medially the pattern is somewhat fluted.

Hinge not clearly observed, but apparently is simple. Muscle scar located near middle of valve, and appears to consist of a compact group of four spots. Other internal features not observed.

Length of holotype, a complete shell 1.38 mm., height 0.90 mm., thickness 0.76 mm.

Relationships.—The subreniform shape of the species, together with its apparently simple hingement and compact muscle scar, ally it to *Candona*. A very large number of living and fossil species of this genus have been described. Their characters are defined primarily on variations in the soft parts, and in many instances complete data as to surface ornamentation of the shell are not available. The writer does not know of other described forms that have the closely spaced minute pitting of this species, or of any that typically are as tumid in the medial portion of the shell.

Two small shells are illustrated (Plate 32, figures 6, 7) as probably representing immature molts of this species. They occur associated with adult forms of *C. pagei*, and do not have larger counterparts in the material studied. The change in shape from the immature molts to the adult involves a decrease in triangularity of outline that results from a progressive heightening of the posterior half of the shell.

Occurrence.—Samples of limestone made up almost entirely of shells of this species were obtained at locality 16. The limestone is lower Eocene, occurring in a zone of interfingering lacustrine Green River and fluviatile Wasatch lithology. The ostracodes are encased in several overgrowth layers of calcium carbonate of sufficient thickness that the ordinary method of stroking the surface with a needle does not spall off the excess material. Larger pieces of the rock were placed in a cloth bag and partly crushed, thereby causing some of the shells to separate from their enclosing calcite. Many specimens were broken, but as many others remained in good condition. The minute surface ornamentation is practically invisible without a very fine grained coating of ammonium chloride. Magnesium oxide as a coating material is unsatisfactory as it forms a too granular deposit.

The new species also occurs at localities 3, 10, 13, 17, 22, 24, and 25.

Types.—Holotype, U.S.N.M. 560232; paratypes 560231, 560233.

CANDONA sp.
Plate 32, figures 11–13

Among examples of very fragile, poorly preserved ostracodes from the Fort Union formation in the Moorhead coal district of Montana are forms that seem to belong to the general group of *Candona candida* (Müller). Because of the incomplete knowledge of their characteristics, it is not feasible to attempt specific designation of the few specimens at hand. A description of the observable features is here presented for the sake of completeness.

Shell elongate-subreniform in side view; greatest height about median; dorsal margin moderately convex, slightly truncate behind, ventral margin gently sinuate, concave in posterior one-third; anterior margin rounded, extended below; posterior margin narrowly rounded, extended below. Surface of valves apparently smooth, but specimens at hand are so coated with limonitic clay as to prohibit clear understanding of surface details. Relative size of valves not known, as no complete examples are present, and edge relationships are uninformative; right valve appears to overlap left along dorsum.

Along hinge, edge of right valve rabbeted on inner side, evidently for reception of edge of left valve. Inner lamellae narrow; line of concrescence and inner margin separate, except midventrally. Marginal pore canals apparently numerous and closely spaced, but their details were not clearly observed. Musculature obscured by matrix.

Length of a figured specimen (Plate 32, figure 11) 1.00 mm., height 0.52 mm.

Occurrence.—Paleocene, locality 1. U.S.N.M. 560240–42.

Genus ERPETOCYPRIS Brady and Norman, 1889

Herpetocypris BRADY and NORMAN, Sars, 1890, Vid. Selsk. Forhandlinger, No. 1, p. 61.
Herpetocypris BRADY and NORMAN, Croneberg, 1894, Bull. Soc. Imp. of Moscow, No. 3.

Herpetocypris BRADY and NORMAN, Brady and Norman, 1896, Trans. Roy. Dublin Soc., vol. V, ser. II, no. 12, p. 722.
Herpetocypris BRADY and NORMAN, Kaufmann, 1900, Rev. Suisse de Zoologie, Ann. Soc. Zool. Suisse, vol. 8, p. 281.
Herpetocypris BRADY and NORMAN, Sars, 1928, Crustacea of Norway, vol. IX, Bergen Museum, Bergen, p. 128.
Erpetocypris BRADY and NORMAN, Beasley, 1945, Proc. Roy. Soc. Queensland, vol. LVI, no. 11, p. 104.
Erpetocypris BRADY and NORMAN, Swain, 1947, Jour. Paleont., vol. 21, no. 6, p. 520.

Sars' correction of the original error in transliteration in forming the name of this genus is contrary to Article 19 of the International Rules of Zoological Nomenclature, and *Herpetocypris* evidently must be suppressed in favor of *Erpetocypris*. This is particularly unfortunate because Brady and Norman, in a later publication (1896) accepted Sars' emendation of their generic name. The synonymy given above is not complete for recent years, but is sufficient to illustrate the accepted spelling of this generic name up to the time of publication of the Rules.

ERPETOCYPRIS? sp.
Plate 32, figures 5, 18

Shell subelliptical in lateral view; dorsal margin gently arched; ventral margin nearly straight to slightly concave medially; terminal margins rounded. Left valve larger than right. Valves moderately convex, greatest thickness about median. Surface finely pitted. Internal features not observed.

Length of a figured specimen (Plate 32, figure 5) 1.00 mm., height 0.57 mm., thickness 0.48 mm.

Remarks.—According to Sars (1928, p. 128), only *Erpetocypris reptans* (Baird), among the forms originally placed in the genus by Brady and Norman, should be retained there, and the others belong in *Prionocypris* Brady and Norman. The present material from the early Tertiary most resembles *Erpetocypris strigata* (Müller), which is one of the forms that Sars referred to *Prionocypris*. The latter genus is not nearly as equal-ended as *Erpetocypris*, and the writer doubts that the forms illustrated as *strigata* should be placed in it. The shells of this group of ostracodes apparently need additional comparative study, and the assignment of fossil representatives is uncertain.

Living examples of *Erpetocypris* occur in quiet fresh water, associated with muddy bottoms, are typically burrowing, and are unable to move about freely in the water (Sars, 1928).

Occurrence.—Paleocene and Eocene, localities 6–9, 16, 18–21, and 23.

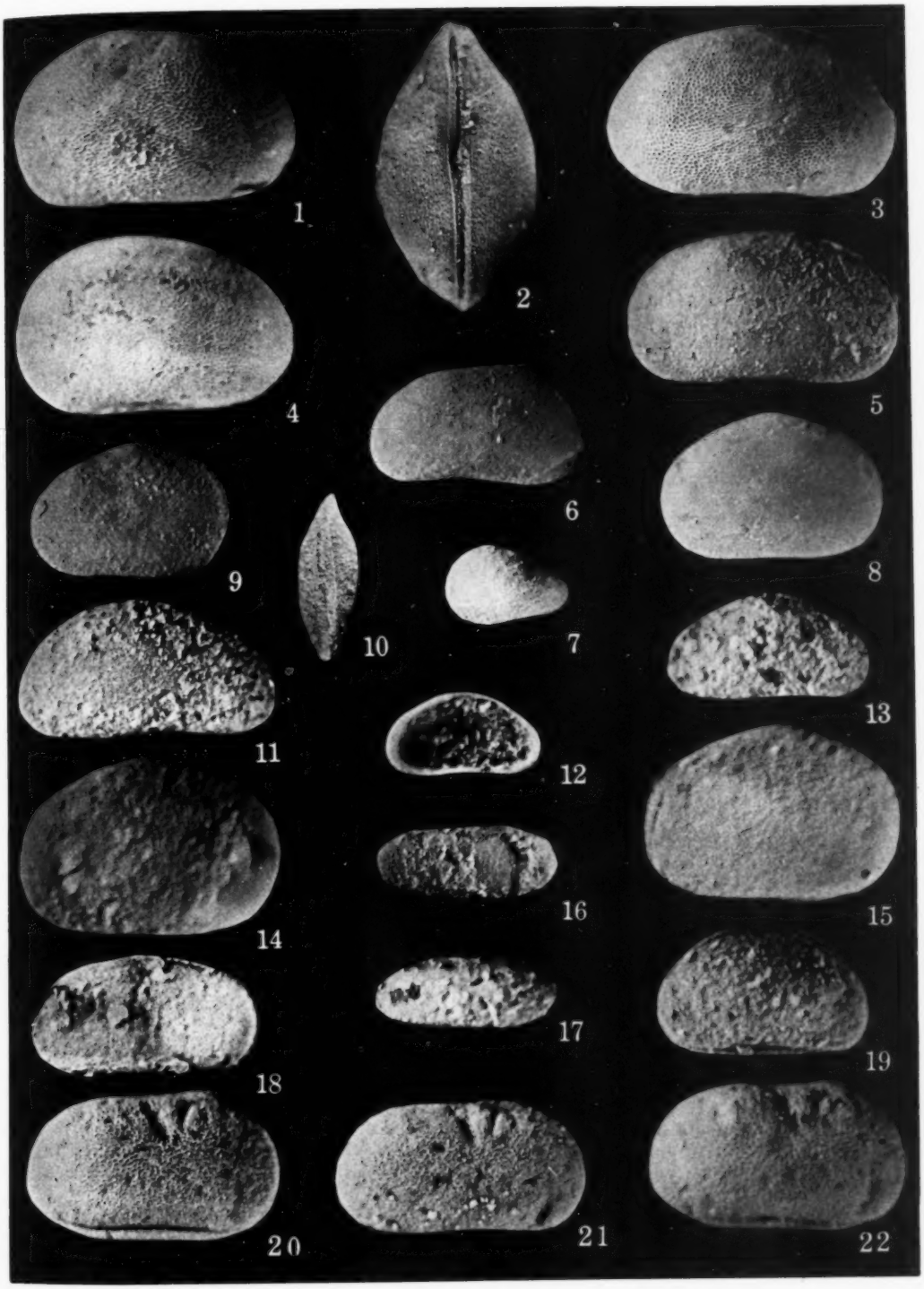
U.S.N.M. 560234, 560247.

Genus SCOTTIA Brady and Norman, 1889
SCOTTIA? sp. aff. S. BROWNIANA (Jones)
Plate 32, figure 19

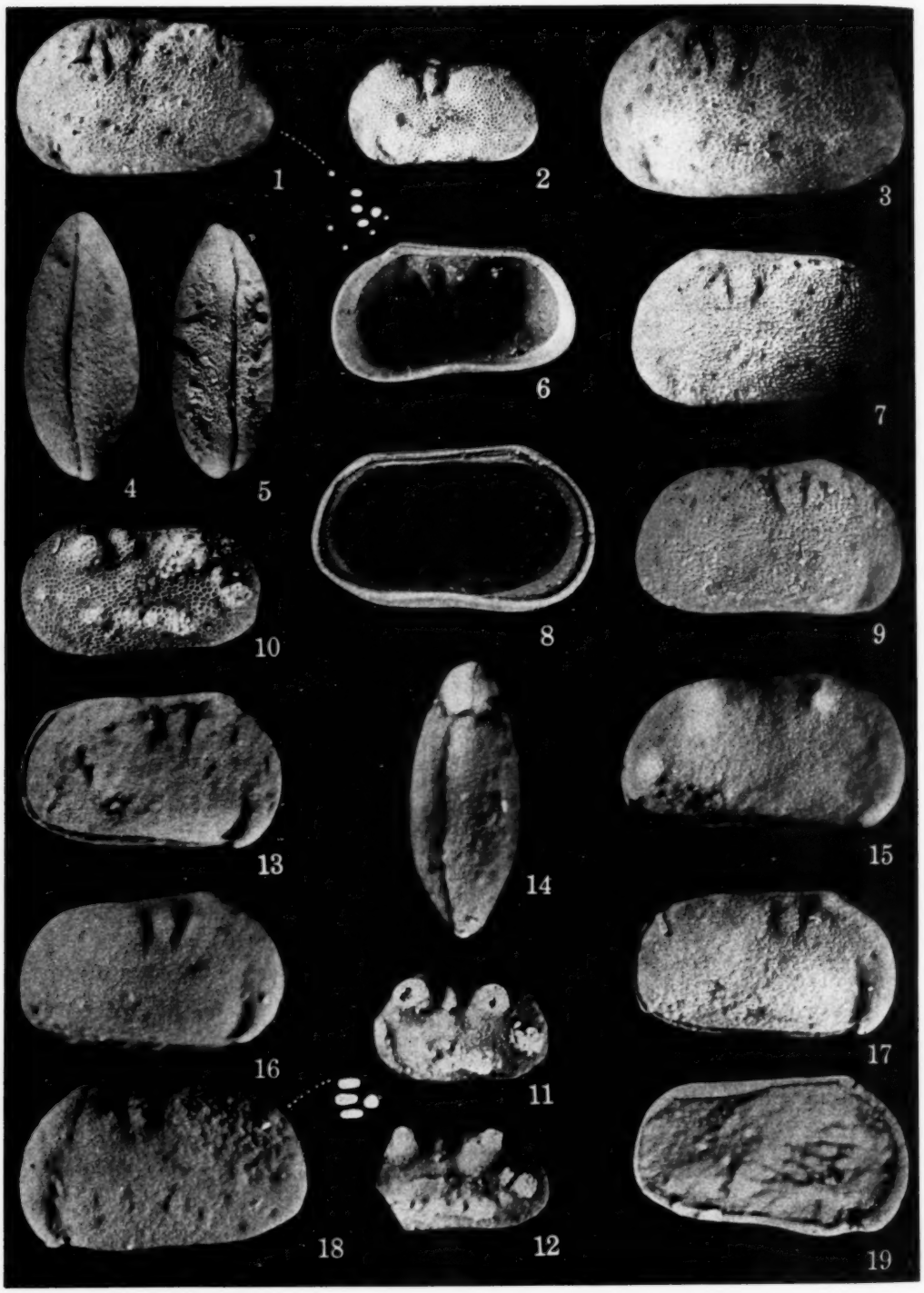
Shell subquadrate in lateral view; hinge margin nearly straight, about half of shell length; ventral margin nearly straight in left valve, slightly concave medially in right valve; terminal margins about equally rounded, truncate above. Left(?) valve

EXPLANATION OF PLATE 32

FIGS. *1–4, 6, 7—Candona pagei* Swain, n. sp. *1, 2,* Left side and ventral views of holotype. *3, 4,* Right and left sides of two paratypes. *6, 7,* Right and left sides of two immature forms here associated with the species. Eocene, locality 16. ×32. USNM 560231-33, 35, 36. (p. 174)
5, 18—Erpetocypris? sp. Right valve views of two specimens. *5,* Eocene, locality 16. *18,* Green River (Eocene), locality 17. ×40. USNM 560234, 47. (p. 176)
8–10, 14, 15—Cyprois cf. *C. marginata* (Strauss). *8–10,* Right sides and dorsal view of two specimens from Eocene, locality 16. *14, 15,* Right sides of two specimens from Flagstaff limestone, locality 7. ×40. USNM 560237–39, 43, 44. (p. 177)
11–13—Candona sp. *11,* Exterior of a right valve. *12, 13,* Interior and exterior of a small right valve and a small left valve. Paleocene, locality 1, ×40. USNM 560240-42. (p. 175)
16, 17—Darwinula cf. *D. stevensoni* (Brady and Robertson). Exterior of two poorly preserved right valves. Paleocene, locality 1. ×40. USNM 560246, 49. (p. 180)
19—Scottia? cf. *S. browniana* (Jones). Right side of a complete shell. Eocene, locality 19. ×40. USNM 560248. (p. 176)
20–22—Ilyocypris arvadensis Swain, n. sp. *20,* Right side of a paratype, Eocene, locality 15. *21,* Exterior of a paratype right valve; Paleocene, locality 2. *22,* Right side of holotype; Eocene, locality 15. ×32. USNM 56045, 50, 51. (p. 178)



Swain, Early Tertiary Ostracoda



Swain, Early Tertiary Ostracoda

larger than right, overlapping it strongly along the hinge and midventrally. Surface evenly convex, its details obscured by recrystallization in the illustrated specimen. Internal features not clearly observed.

Length of illustrated specimen 0.86 mm., height 0.52 mm., thickness 0.38 mm.

Remarks.—This form is very close to *Cypris browniana* Jones (1856, pl. 1, figs. 1a-e). Brady and Norman (1889, pl. IX, figs. 23, 24) referred Jones' Tertiary form, together with Recent examples, to their new genus *Scottia*. The Recent examples figured by them, however, are less quadrate in outline and are nearly equivalved, as contrasted to the marked left-valve overlap noted by Jones. Because the specimen illustrated here is closer to Jones' Tertiary form than to the described Recent ones, and because its internal features are obscure, it is only questionably assigned.

Occurrence.—Rare in Green River formation (Eocene) at locality 19.

U.S.N.M. 560248.

Genus CYPROIS Zenker, 1854

Shell subovate in lateral view; dorsal margin strongly arched, greatest height about median; ventral margin nearly straight; anterior margin broadly rounded; posterior margin sharply curved and somewhat extended ventrally, subtruncate above. Valves nearly equal in size, the left slightly larger; viewed from above, greatest thickness median, greatest convexity posterior to midlength, anterior end compressed. Ventral margins somewhat compressed. Surface smooth.

Hinge simple. Muscle scar in *C. marginata* (Strauss) consists of a compact group of four spots together with two smaller spots in the lower part of the group. Inner lamellae broadest anteriorly; marginal pore canals numerous anteriorly, fewer posteriorly. (Description based on illustrations by Brady and Norman, 1889, pl. VIII, figs. 18, 19; and by Sars, 1928, pl. XLVII).

Cyprois was established by Zenker in 1854 for ostracodes like *Cypris* but with almost completely divided eye, and with the mucous gland of the male genital apparatus differently constructed (Jones, 1856, p. 12). Brady and Norman (1889, p. 97) point out other differences in the appendages. Zenker included two different types of shells in the original description: *Cypris dispar* Fischer, which exhibits the characters described above; and *Cypris monacha* (Müller), which is ribbed or keeled on the ventral surface. Brady and Norman (1899, p. 97) showed that although the male reproductive organs in the two species are similar, there is sexual dimorphism exhibited by the shells of *C. monacha* which is lacking in *C. dispar*. They refer the former to *Notrodomas* Lilljeborg, 1853, and consider *Cyprois dispar* to be a synonym of *C. flava* (Zaddach). G. O. Sars (1928) placed both *C. dispar* and *C. flava* in synonymy with *C. marginata* (Strauss).

Genotype.—*Cypris marginata* Strauss.

Habitat.—Fresh water throughout Europe and in North America (Sars, 1928, p. 104), in small ponds and ditches.

CYPROIS cf. C. MARGINATA (Strauss)
Plate 32, figures 8–10, 14, 15

Cypris marginata STRAUSS, 1821, Mém. Mus. Paris, vol. 7, p. 59, pl. 1, figs. 20–22.

EXPLANATION OF PLATE 33

FIGS. *1–9—Ilyocypris arvadensis* Swain, n. sp. *1*, Exterior of a paratype left valve; Paleocene, locality 2. *2*, Exterior of an immature left valve showing broad ventral swelling that is lost in the adult, but which has a nodose counterpart in the tuberculate variety; Paleocene, locality 2. *3, 7, 9*, Exteriors of paratype left and right valves; Paleocene, locality 6. *4, 5*, Ventral and dorsal views of two paratype shells; Eocene, locality 15. *6, 8*, Interiors of paratype right and left valves; Eocene, locality 14. *1, 2, 4–9* ×32; *3* ×40. USNM 560252–60. (p. 178)

10–12—Ilyocypris arvadensis tuberculata Swain, n. var. *10*, Exterior of holotype, a left valve. *11, 12*, Exteriors of immature left valves showing the strongly elevated nodes. Paleocene, locality 6. ×40. USNM 560261, 62. (p. 179)

13–19—Cypridea bisulcata Swain, n. sp. *13*, Right side of holotype, a complete shell, Flagstaff limestone, locality 9. *14*, Ventral view of a paratype shell, Flagstaff limestone, locality 9. *15–17*, Right sides of paratype shells; Flagstaff limestone, localities 10, 8, and 8, respectively. *18*, Left side of a paratype shell; Flagstaff limestone, locality 9. *19*, Interior of a paratype left valve; Flagstaff limestone, locality 8. ×40. USNM 560264–70 (p. 180)

Cypris flava ZADDACH, 1844, Syn. Crust. Prodr., p. 33.
Cypris dispar FISCHER, 1851, Ueber das Genus Cypris, p. 142, pl. i, figs. 1–12, pl. ii, figs. 1–6.
Cyprois dispar (FISCHER), Zenker, 1854, Archiv für Naturgesch., p. 81.
Cyprois dispar (FISCHER), Lilljeborg, 1883, Int. Fish. Exhib., London, Sweden Cat., p. 147.
Cyprois flava (ZADDACH), Brady and Norman, 1889, Trans. Roy. Dublin Soc., vol. IV, ser. II, sec. 1, p. 97, pl. VIII, figs. 18, 19, pl. XII, figs. 13–21, 38.
Cyprois marginata (STRAUSS), Sars, 1928, Crustacea of Norway, p. 103, pl. XLVII, fig. 2, pl. XLVIII.

Shell subovate in side view; dorsal margin strongly arched; ventral margin nearly straight; anterior margin somewhat more broadly rounded than posterior. Valves approximately equal in size, only moderately convex; greatest thickness about median. Surface smooth.

Hinge not clearly observed but apparently simple; muscle scar and other internal features not observed.

Length of a figured specimen (Plate 32, figure 14) 1.05 mm., height 0.74 mm., thickness 0.43 mm.

Remarks.—As compared to *Cypris*, the shell of *Cyprois* is less convex, more strongly arched dorsally, and tends to be compressed terminally. The specimens at hand are close to *C. marginata*, and although the examples from the Flagstaff limestone are a little larger than those from the beds having Green River lithology in Carbon County, Utah, there seems to be no reason to separate them.

Occurrence.—Paleocene(?) and Eocene, localities 7, 8, 9, 16, 17, and 22.

U.S.N.M. 560237–39, 560243–44.

Genus ILYOCYPRIS Brady and Norman 1889

ILYOCYPRIS ARVADENSIS Swain, n. sp.
Plate 32, figures 20–22, plate 33, figures 1–9

Shell subquadrate in side view; greatest height about one-fifth from anterior end; hinge margin straight, about three-fifths of shell length, and defined by broadly obtuse cardinal angles; ventral margin nearly straight, slightly concave medially where edges of valves bend gently inward; anterior margin broadly rounded, truncate above; posterior margin more narrowly rounded, extended below. Left valve larger than right, overlapping and extending beyond the other most strongly along ventrum; as viewed dorsally, valves moderately convex, greatest thickness slightly post-median.

Anterodorsal surface of each valve bears two short, narrow, subvertical sulci that define a small lobe; anteriorly in most specimens is a third shorter sulcus that defines a second small lobe. Anteroventrally on right valve a shallow groove occurs parallel to anterior margin and terminates ventrally in a small pit; corresponding feature on left valve much less distinct. Entire surface of each valve finely pitted; medially the pits swirl about the position representing muscle-scar area on inner surface. Several specimens other than the holotype bear two blunt nodes that lie respectively antrad and postrad of sulcate area of shell.

Hinge of left valve consists of a narrow groove for reception of the slightly rabbeted edge of right valve. Muscle scar consists of a subvertical row of three spots, together with a more posterior spot and about five tiny accessory spots (Plate 33, figure 1). Inner lamellae slope gently toward interior of valve except midventrally where they are almost perpendicular to plane of commissure; line of concrescence and inner margin not coinciding. Marginal pore canals numerous, arranged more or less in pairs; near their inner termination pores become larger and form a scalloped pattern along line of concrescence.

Length of holotype 1.19 mm., height 0.69 mm., thickness 0.48 mm.

Relationships.—The new species is very close to the Recent fresh-water *Ilyocypris bradyi* Sars and to *I. bohli* Triebel, from the upper Oligocene of Germany, but differs from both in possessing an anteroventral groove that is particularly well defined on the right valve.

The immature molts evidently are smaller thin-shelled representatives that differ from the adults only in that they bear a broad, low, ridgelike swelling on the ventral surface of the valves (Plate 33, figure 2). Betty Kellett Nadeau (personal communication) finds that in certain Upper Jurassic metacyprids she is now studying, the immature forms are nodose, but the adults of the same species are only sparingly nodose or lack nodes entirely. Following the discussion

with Mrs. Nadeau, the writer reexamined the material from which was obtained the nodose variety of *I. arvadensis* described below. Both nodose and non-nodose small and large shells are present in the collection (Paleocene, locality 6). One of the two large nodose shells bears two blunt dorsomedian nodes of the type noted on several adult shells from other localities. The second of the two larger nodose shells is here figured (Plate 33, figure 10) as the tuberculate variety. It is smaller than most of the typical adult members of the species, and may actually be an immature example. In addition to dorsomedian and posterior nodes, it bears a nodose submedian ridge which is lacking on the other adult shells typical of the species, but which is very strongly developed on the immature nodose forms (Plate 33, figures 11, 12), and is weakly developed on the immature non-nodose forms (Plate 33, figure 2). It seems reasonable to recognize a rare, ridge-bearing, nodose variety as distinct from typical members of the species that bear a submedian ridgelike swelling only in the immature molts.

Occurrence.—Paleocene and Eocene, localities 2, 3, 6, 7, 13, 14, and 15.

Types.—Holotype, U.S.N.M. 560251; paratypes, 560245, 560250, 560252–60.

Ilyocypris arvadensis tuberculata Swain, n. var.

Plate 33, figures 10–12

Principal features of shell as in typical *I arvadensis*; surface anterior and posterior to sulcate area bears two large rounded nodes; posterior surface bears one to three smaller nodes; ventral surface bears a longitudinal row of four papillate nodes situated along a ridgelike swelling.

Length of holotype, a small left valve, 0.88 mm., height 0.50 mm.

Remarks.—The new variety is similar to the Tertiary and Recent *I. gibba* (Ramdohr), but that form bears a prominent spinelike projection in the ventral half of the shell, rather than the nodose ridge of the example under discussion.

Occurrence.—Paleocene, locality 6.

Types.—Holotype, 560261; paratypes 560262.

Subfamily Cypridеinae Martin, 1940

Rostrocyprinae Anderson; 1939, Ann. and Mag. Nat. Hist., vol. III, no. 15, p. 293.

Genus Cypridea Bosquet, 1852

Ulwellia Anderson, *Morinina* Anderson, *Langtonia* Anderson, *Cyamocypris* Anderson; 1939, Ann. and Mag. Nat. Hist., vol. III, no. 15, pp. 300, 302, 304, and 305 respectively.

In his study of Purbeck and Wealden species of this problematical group of freshwater ostracodes, Anderson (1939) proposed the subfamily Rostrocyprinae to include Cypridae that possess an anteroventral beak and notch as typically developed in *Cypridea* Bosquet. In so doing, as pointed out by Martin (1940, p. 281), Anderson violated Article 4 of the International Rules of Zoological Nomenclature with respect to the formation of a subfamily name.

Anderson also acted in contradiction to Opinion 46 of the Commission on Zoological Nomenclature in proposing *Cypridea punctata* (Forbes) as the genotype of Cypridea. When Bosquet introduced *Cypridea* (1852, p. 47) he stated that the new genus applied to "Wealden" species possessing an anteroventral beak and notch that had previously been assigned to *Cypris* Müller. He mentioned no species by name, but referred to "eight or nine" species described by Sowerby (1836), Roemer (1839), and Dunker (1846) from the "Wealden" (now Purbeck and Wealden) of Germany and England. Seven of these are: *Cypris tuberculata* Sowerby, *C. spinigera* Sowerby, *C. granulosa* Sowerby, *C. oblonga* Roemer, *C. striatopunctata* Roemer, *C. laevigata* Dunker, and *C. rostrata* Dunker. The eighth and ninth species referred to probably are *Cypris valdensis* Fitton and *C. fittoni* Mantell which appeared along with Sowerby's species in Fitton's "Strata below the Chalk" (1836). According to Opinion 46, one of these, preferably one of the first seven distinctly referred to, must be selected as the genotype. *Cypris punctata* Forbes (1855), not known to Bosquet in 1852, and not one of the first species to be used in connection with the genus *Cypridea*, is unavailable for selection as genotype on several counts.

It is here suggested that *Cypris granulosa* Sowerby be considered the type of *Cypridea*. This form evidently is well under-

stood, having been described in detail by Jones (1885, pp. 340–42) and by Martin (1940, pp. 290–92), is widely distributed in the standard Upper Jurassic and Lower Cretaceous rocks of Europe, and was one of the first three to be refered to the genus (Jones in Morris' Cat. of Brit. Foss., 2nd Ed., p. 104, 1854).

CYPRIDEA BISULCATA Swain, n. sp.
Plate 33, figures 13–19

Shell subquadrate in lateral view; hinge margin nearly straight to slightly sinuous, about two-thirds of shell length; anterior cardinal angle distinct and lying at position of greatest height; posterior angle more obtuse, less distinct, the margin there curving gradually rather than with pronounced angulation; ventral margin nearly straight to slightly sinuous, converging moderately backward with respect to dorsum; anterior margin broadly rounded, truncate above; posterior margin more narrowly rounded. Left valve larger than right, overlapping and extending beyond the other most noticeably along ventral and posterior margins.

Surface of valves in holotype very faintly and minutely punctate; in some other specimens at hand punctae are absent. Anterodorsal surface bears two short sulci separated by a low rounded lobe. Anteroventral marginal bend bears a more or less well defined hood and notch and a small beak. In most specimens beak is not strongly extended.

Hinge of left valve consists of the narrowed and slightly rabbeted valve-edge which overlaps narrowed edge of right valve. Muscle scar consists of a submedian, vertical, slightly curved row of three elongate spots, together with a slightly more posterior rounded spot. Inner lamellae narrow, slightly broader anteriorly than elsewhere.

Length of holotype, a complete specimen 1.00 mm., height 0.62 mm., thickness 0.38 mm.

Relationships.—The species under discussion and *Ilyocypris arvadensis*, n. sp. are clearly an example of isomorphism. The anteroventral oblique groove on the surface of the latter species mimics the cyprideid hood and notch, but in ventral view the gently curved anteromarginal bend in *Ilyocypris* differs markedly from the striking angulation of the line of commissure in *Cypridea*. In their general shape, bisulcation, simple hingement, musculature, and more or less punctate surfaces, the two forms are otherwise nearly indistinguishable. Several specimens of *Cypridea bisulcata* even have small nodes on the dorsal surface of the valves, as do some of the examples of *Ilyocypris arvadensis*.

Because of its sulcation, the new species differs from other described members of the genus, and recognition of a distinct subgenus might be justified. For the time being, such treatment would serve no stratigraphic purpose, as no other cyprideids have been encountered in the Tertiary of the region.

Occurrence.—Eocene, localities 8–12, 22, and 25.

Types.—Holotype, U.S.N.M. 560264; paratypes 560265–70.

Family DARWINULIDAE Brady and Norman, 1889
Genus DARWINULA Brady and Norman, 1889

Polycheles BRADY and ROBERTSON, 1870, Ann. and Mag. Nat. History ser. IV, vol. VI, p. 25 (name preoccupied).
Darwinella BRADY and ROBERTSON, 1872, Ann. and Mag. Nat. History. ser. IV, vol. IX, p. 50 (name preoccupied).

DARWINULA cf. D. STEVENSONI (Brady and Robertson)
Plate 32, figures 16, 17

Polycheles stevensoni BRADY and ROBERTSON, 1870, Ann. and Mag. Nat. History, ser. IV, vol. VI, p. 25, pl. VII, figs. 1–7, pl. X, figs. 4–14.
Argilloecia aurea BRADY and ROBERTSON, 1870, Ann. and Mag. Nat. History, ser. IV, vol. VI, p. 16, pl. VIII, figs. 4, 5.
Darwinella stevensoni (BRADY and ROBERTSON), Brady and Robertson, 1872, Ann. and Mag. Nat. History, ser. IV, vol. X, p. 50.
Darwinella stevensoni (BRADY and ROBERTSON), Brady, Crosskey, and Robertson, 1874, Post-Tertiary Entomostraca, p. 141, pl. II, figs. 13–17.
Darwinula stevensoni (BRADY and ROBERTSON), Brady and Norman, 1889, Trans. Roy. Dublin Society, ser. II, vol. IV, sec. 1, pp. 122–23, pl. X, figs. 7–13, pl. XIII, figs. 1–9, pl. XXIII, fig. 5.

Shell elongate-oval in side view; dorsal and ventral margins nearly straight and subparallel; terminal margins rounded, anterior margin slightly narrower than the

other. Valves nearly equal in size, the right slightly larger; both valves moderately convex. Surface smooth.

Hinge less than half of shell length; that of left valve consists of a narrow groove for reception of hinge surface of right valve. Muscle scar not observed. Inner lamellae very narrow; line of concrescence and inner margin apparently coinciding.

Length of a figured specimen (Plate 32, figure 16) 0.65 mm., height 0.29 mm.

Remarks.—*Darwinula stevensoni* is widely distributed in rivers and lakes in Europe (Brady and Norman, 1889, p. 122) and Sars reported its occurrence in North America (1928, p. 146). The rather poorly preserved specimens from the Paleocene of Montana cannot be distinguished from it. Upper Jurassic examples are generally higher with respect to length, but otherwise little is known of fossil representatives of the genus.

Occurrence.—Paleocene, locality 1.

U.S.N.M. 560246, 560249.

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THE PERMIAN FUSULINIDS OF TIMOR

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ABSTRACT—All available information concerning fusulinids from the Permian of Timor is summarized in this report. Five species are described and illustrated as *Palaeofusulina weberi* (Schubert), *Schwagerina brouweri*, n. sp., *S.? molengraaffi* (Schubert), *S.* sp., and *Parafusulina wanneri* (Schubert). The first occurs in Portuguese Timor, and the last four occur in Netherlands Timor in the region of Kapan, Basleo, and Poetain. All of the fusulinids seem to be of Leonardian or older Permian ages.

INTRODUCTION AND ACKNOWLEDGEMENTS

THE Permian of Timor is famous for its prolific invertebrate faunas, particularly faunas of Mollusca and Echinodermata, and for what seem to be somewhat unique associations of certain of the invertebrates. Fusulinids are abundant in marine Permian rocks of many parts of the world, and they have been found to be among the most reliable fossils for correlation and zonation of the Permian. However, only one short report (Schubert, 1915) describes Timor fusulinids. Samples of limestone illustrated by Schubert demonstrate that fusulinids are exceedingly abundant in some strata, but the variety seems to be small. Brouwer (1942) and others have mentioned limestone composed almost exclusively of tests of fusulinids at many places in Netherlands Timor. Professor H. A. Brouwer, Director of the Geological Institute, University of Amsterdam, recently sent me five large samples of Permian limestone that were collected by members of his 1937 expedition to Timor. All of these samples contain abundant fusulinid Foraminifera, including abundant specimens of one previously described form and less abundant specimens of an undescribed species. The classification of fusulinids formerly described from Timor is summarized below, and all new information obtained from the collections at hand is included.

I wish to express my sincere thanks to Professor Brouwer for the opportunity of studying this valuable material. Financial aid in completing this report was given by the Research Committee of the University of Wisconsin from funds furnished by the Wisconsin Alumni Research Foundation.

GENERAL CONSIDERATIONS

Members of several geological expeditions have explored the Island of Timor during the last forty years, including those directed by J. Wanner in 1909 and 1911, by G. A. F. Molengraaff in 1911, by F. Weber in 1911, and by H. A. Brouwer in 1937. The published results of these expeditions have demonstrated that some of the most prolific Permian faunas known occur on Timor. Permian fossils from Timor have been described by various specialists in numerous publications. Many of these papers were published in the sixteen volumes of *Paläontologie von Timor*, edited by J. Wanner, 1914 to 1929, and in the four volumes of *Geological Expedition to the Lesser Sunda Islands*, edited by H. A. Brouwer, 1940 to 1942. Representatives of the phyla Coelenterata, Mollusca, and Echinodermata have received particular attention. Seemingly the last representatives of several groups of Paleozoic fossils occur in the Permian of Timor.

Although Permian rocks occur at the surface in many parts of Timor, the exposures are small, the strata are highly distorted, and exposures are poor. As a result of these unfavorable conditions, a complete section of all Permian rocks on the island has not been reconstructed. Furthermore, a complete section of the Permian rocks has not been published for any local area. Most of the fossils collected from one general area have been described and discussed as a unit and have been designated by names of villages or political divisions nearby. Some collections were purchased from natives and the exact localities from which they came are undetermined although the gen-

eral areas from which they came are known. It has been stated that some large faunas were obtained from residual soils, and the original rocks were not observed in an unweathered state. In other places, the fossil-bearing Permian rocks are intermixed with much younger rocks in complex structures.

make a stratigraphical sequence of the individual layers, in the first place on account of their isolated occurrence above mentioned, but also because the larger localities yield their fossiliferous material exclusively from a thick crust of weathered soil.

It is therefore very lucky that the common occurrence of ammonoids, these important fossils for local and interregional correlations . . .

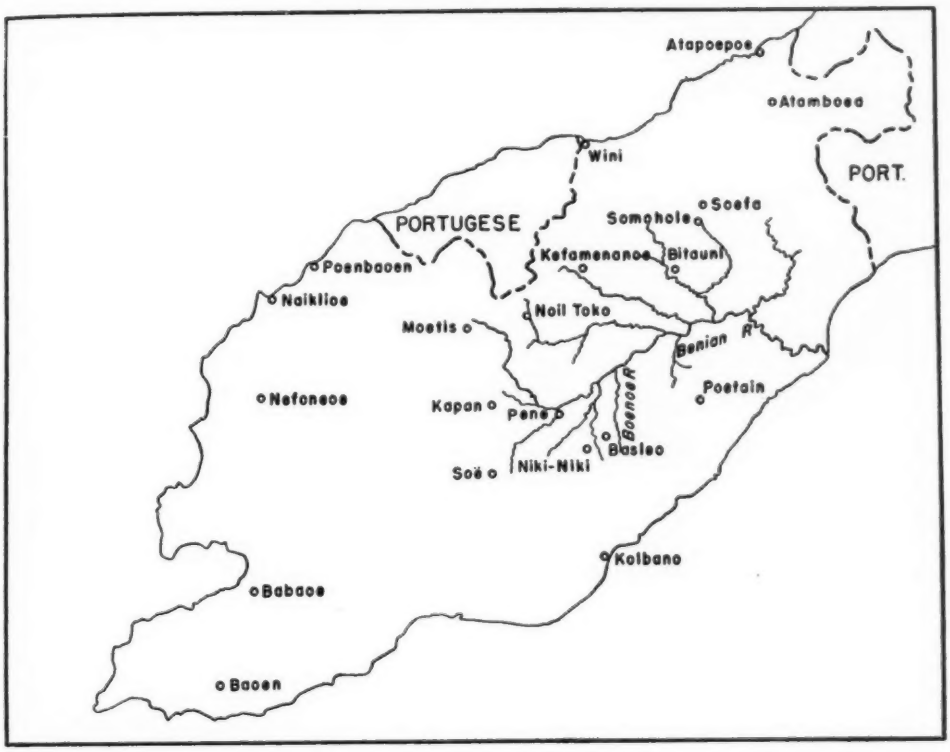

FIG. *1*—Outline map of Netherlands Timor showing the locations of villages for which some of the Permian faunas were named and some other localities mentioned in this report.

Oyens (1938) summarized the local problem of stratigraphy in the area of Basleo as follows:

It is a known fact that the Paleozoic rocks in the vicinity of Basleo contain the richest layers of marine Permian invertebrates of the world. The localities consist for the greater part of isolated occurrences of limestones, tuffaceous rocks, marls and conglomerates, separated from each other in some cases by Permian basic eruptive rocks, but more generally folded together in a varied series of Mesozoic and Old-Tertiary (Eocene) sediments, whilst also a large amount of bigger and smaller faults is responsible for the separated occurrence of the individual localities.

In the field it has been impossible so far to enable us to compare the different localities as to their stratigraphical position.

The Permian cephalopods, and especially the ammonoids, include the major fossils on which the faunas from the different localities in Timor have been compared with one another and correlated with Permian faunas of other areas. For many years, four major Permian faunal units of Timor have been recognized. They were designated Somohole, Bitauni (Bitaoeni), Basleo, and Amarassi, respectively, as interpreted from oldest to youngest. The first three names are from

villages in central Netherlands Timor and the last is from the province of Amarassi in Netherlands Timor. Widely different ages of Permian fossils have been indicated from studies of the faunas from some of these localities. Oyens (1938) identified a fauna from the Basleo area under the term Tae Wei. He considered the Tae Wei fauna intermediate in age between the Bitauni fauna and the Basleo fauna. Simons (1940) recognized a sixth fauna (Lidak fauna) of early Bitauni age in the Lidak Mountain region, west of Atamboea in northeastern Netherlands Timor. The accompanying outline map of Netherlands Timor (Fig. 1) shows the locations of the villages for which some of these faunas were named, as well as some other locations mentioned in this report.

Miller and Furnish (1940) compared the Timor ammonoid faunas with American Permian faunas, and they correlated the Somohole fauna with the zone of *Properrinites* of the Wolfcampian, the Bitauni fauna with the zone of *Perrinites* of the Leonardian, part of the Basleo fauna with the zone of *Waagenoceras* of the lower Guadalupian, and the Amarassi fauna with the zone of *Timorites* of the upper Guadalupian. These workers also recognized that several ages of ammonoids are present in the faunas from near Basleo.

TIMOR FUSULINIDS

In 1915, Schubert studied seventeen collections of fusulinids from the Permian of Timor that had been obtained by members of two expeditions directed by Wanner, an expedition directed by Molengraaff, and another directed by Weber. Schubert described four species from these collections as *Fusulina granum-avenae* Roemer, 1880; *F. wanneri* Schubert, 1915; *F. molengraaffi* Schubert, 1915; and *F. weberi* Schubert, 1915. The first three were identified from numerous localities in the drainage area of the southwestern headwaters of Benain River, Netherlands Timor. *F. wanneri* was reported also from a southeast tributary of the Bissori, northwest of Pualaca. *F. granum-avenae* and *F. weberi* were identified from a sample collected east of Pualaca, Portuguese Timor, and from samples collected on the north slope of Aubeon.

The samples submitted to me were obtained from large blocks of limestone exposed on Boenoe River (Noil Boenoe) easterly from Niki-Niki and in the general area from which the Basleo fauna was obtained. All of the samples have been extensively sectioned. They contain two species that are described below as *Schwagerina brouweri*, n. sp., and *Parafusulina wanneri* (Schubert). The specimens described and illustrated by Schubert as *F. granum-avenae* are here referred to *Schwagerina brouweri*, n. sp., and *S.* sp. The form described by Schubert as *F. molengraaffi* is described below as *Schwagerina? molengraaffi*, and that described by Schubert as *F. weberi* is described below as *Palaeofusulina weberi*.

The fusulinids of Timor are not closely similar to the complex Tethyan fusulinid faunas so widespread in other parts of the

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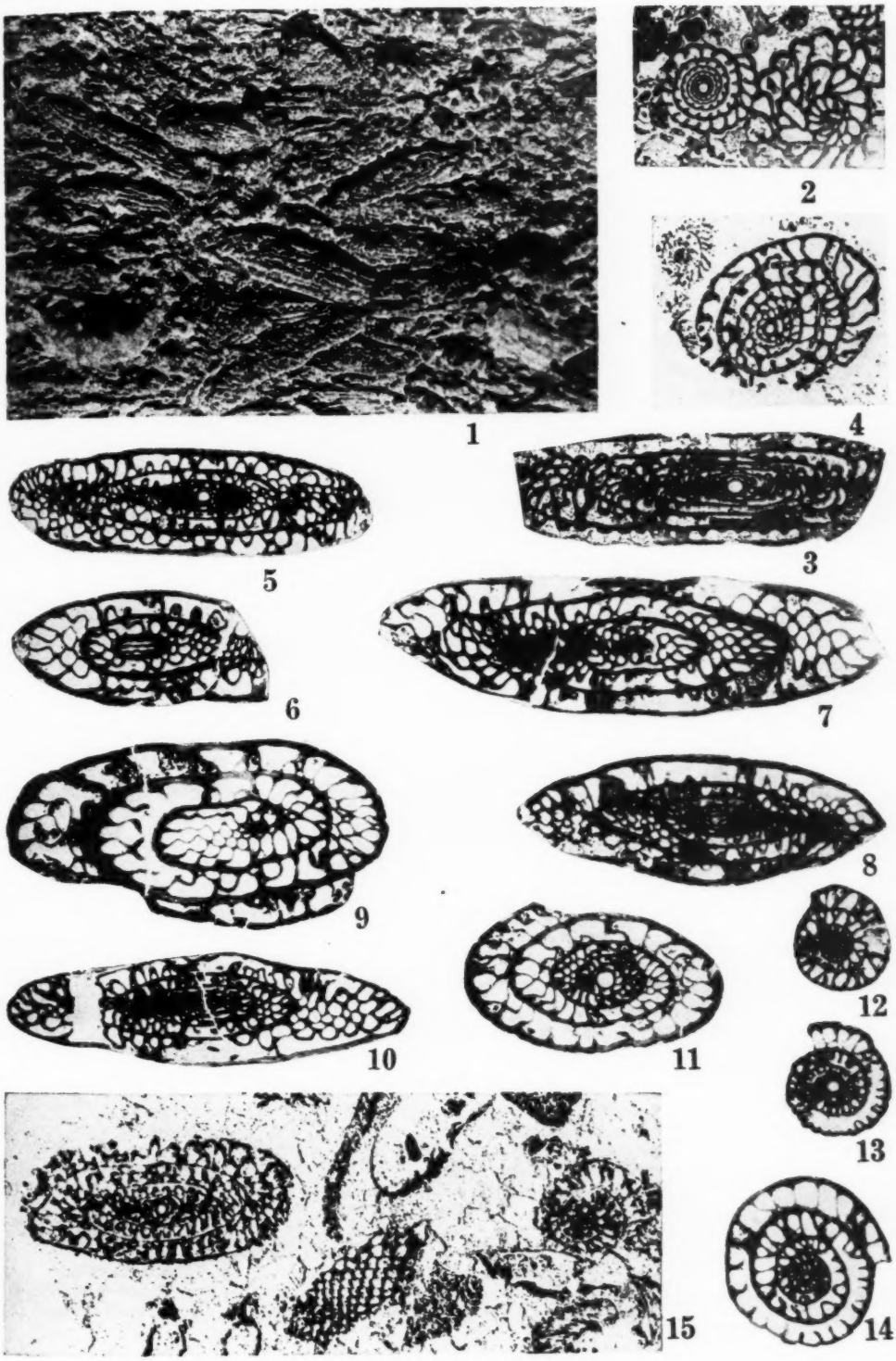
EXPLANATION OF PLATE 34

FIGS. *1–3—Schwagerina? molengraaffi* (Schubert). *1*, Limestone with abundant specimens, ×5; *2*, part of a section of limestone with a sagittal section and a parallel section showing scalloped polar regions, ×10; and *3*, axial section of the holotype, ×10. From along the road from Kapan to Pene, Netherlands Timor. (All after Schubert.) (p. 188)

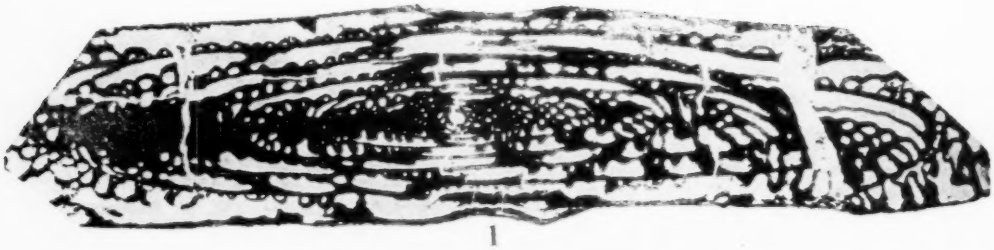
4—Schwagerina brouweri Thompson (?), n. sp., and *Palaeofusulina weberi* (Schubert). Section of limestone with an oblique sagittal section of *S. brouweri* (?) and a parallel section of *P. weberi*, ×10. From east of Pualaca, Portuguese Timor. (After Schubert.) (p. 187)

5–14—Schwagerina brouweri Thompson, n. sp. *5*, Axial section of the holotype; *6*, *7*, *9*, *10*, tangential sections of paratypes; *8*, axial section of a paratype; *11*, oblique section of a paratype; *12*, parallel section of a paratype; and *13*, *14*, sagittal sections of paratypes, all ×10. From limestone blocks in Boenoe River east of Niki-Niki, Netherlands Timor. (p. 187)

15—Palaeofusulina weberi (Schubert). Axial section of the holotype on the left side, tangential section of a paratype in the lower center showing the septal fluting, and a parallel sections of a paratype on the right, ×20. East of Pualaca, Portuguese Timor. (After Schubert.) (p. 186)



Thompson, Permian Fusulinids



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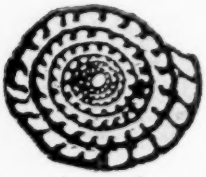

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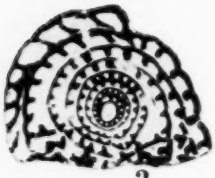

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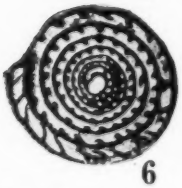

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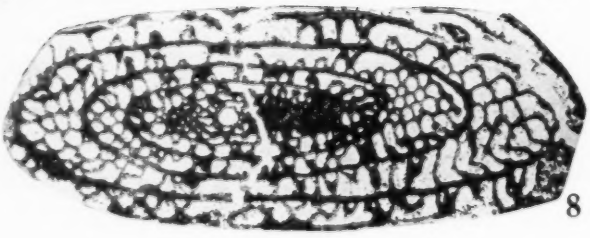

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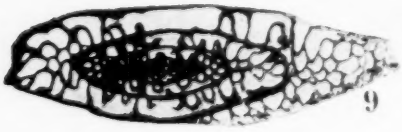

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Thompson, Permian Fusulinids

Eastern Hemisphere. The large fauna described from the Padang Highlands of western Sumatra (Lange, 1925) does not contain any forms here recognized from Timor. The small fauna of verbeekinids described from the Island of Letti (Schubert, 1915) has nothing in common with the Timor faunas. Furthermore, the only fusulinids known from Australia (Chapman and Parr, 1937) are not closely similar to forms known from Timor.

The Permian of the Salt Range of India contains a fusulinid fauna that seems closely similar in age to the Timor fauna. In fact, a species from the Lower Productus limestone (Dunbar, 1933), *Parafusulina kattaensis* (Schwager), is closely similar in structure to *P. wanneri* (Schubert) described below from Timor. Local conditions in these areas seem to have been similar. Shells of the fusulinids are very abundant at both places, but the faunas contain few forms. The age relationship between the complex Tethyan fusulinid faunas and the Timor faunas, as well as the Indian faunas, is not known with certainty. The areas of Timor and India may be located on opposite marginal areas of the Tethys and may not contain the more complex elements of the Tethys because of environment. It seems probable, however, that *Parafusulina wanneri* from Timor and *P. kattaensis* from India are more primitive than most, if not all, of the complex verbeekinid and neoschwagerinid faunas of the Eastern Hemisphere.

Parafusulina caracorumensis (Merla) from Karakorum is similar in many respects to *P. wanneri*. Reichel (1940) found a very primitive Tethyan fusulinid fauna in Karakorum stratigraphically above the zone of *P. caracorumensis*. This Tethys fauna included representatives of *Staffella*, *Nankinella?*, *Schubertella*, *Neofusulinella*, *Dunbarinella*, and *Misellina*. The close similarity of the *Parafusulina* fauna of Karakorum and *P. wanneri* suggests they are closely similar in age. It would, therefore, seem probable that the Timor form is older than most, if not all, early Tethyan faunas of neoschwagerinids and verbeekinids.

The genus *Palaeofusulina* was described from the Permian of French Indo-China (Deprat, 1912), and it has been reported from the Caucasus (Licharew, 1926) and from the Permian of Karakorum (Reichel, 1940). The ages of the rocks in Indo-China and the Caucasus are not known with certainty. The form from Karakorum described as *Palaeofusulina* probably is referable to *Gallowaiinella* Chen. Also, the Caucasian form may not be referable to *Palaeofusulina*. The stratigraphic distribution of *Palaeofusulina* is not completely known, and the occurrence *P. weberi* in the Permian near Pualaca, Portuguese Timor, does not furnish much stratigraphic information. However, this form is associated with a form of *Schwagerina* that would seem to demonstrate that it is early Permian in age.

Schwagerina brouweri, n. sp., is a typical form of the genus. It does not have heavy axial fillings and tightly coiled early volutions as found in most late Permian forms referred to *Schwagerina*. It is associated with *Parafusulina wanneri* (Schubert) and probably is of Leonardian age.

The form described by Schubert as *Fusulina molengraaffi*, although well described for that time, was not sufficiently described or illustrated for generic identification with more recent classifications. In regard to shape and several other respects, it seems possible that this form is referable to *Parafusulina*. However, its small size would sug-

EXPLANATION OF PLATE 35

FIGS. *1–6*—*Parafusulina wanneri* (Schubert). *1*, Axial section here selected as the holotype, ×10; *2*, sagittal section of a paratype, ×10; *3*, *5*, *6* sagittal sections, ×10; and *4*, enlarged part of a tangential section showing abundant septal pores in the right end and the development of the cuniculi on the left side, ×23. *1* and *2* are from the spring area of Lassi Creek between Bele and Niki-Niki, and all others are from limestone blocks on Boenoe River east of Niki-Niki, Netherlands Timor. (*1*, *2* after Schubert.) (p. 187)

7, *8*—*Schwagerina* sp. *7*, Sample of limestone with abundant specimens of this form, ×1.2, and *8*, oblique section showing axial fillings and highly fluted septa, ×10. From between Poetain and Besikama-Ebene, Netherlands Timor. (After Schubert.) (p. 189)

9—*Schwagerina brouweri* Thompson, n. sp. Tangential section of a paratype, ×10. From limestone blocks on Boenoe River east of Niki-Niki, Netherlands Timor. (p. 189)

gest that it probably is an elongate form of *Schwagerina*. For the present at least, I am referring it with question to *Schwagerina*. If referable to *Parafusulina*, it is a primitive form of that genus and probably is of early Permian age.

The limestone samples from Boenoe River contain abundant specimens referable to the form described by Schubert as *Fusulina wanneri*. Many axial sections obtained from these samples are almost identical to the specimen selected below as the holotype of that form. Also, measurements obtained from my specimens compare very closely with measurements published by Schubert. All evidence indicates that this form is referable to *Parafusulina*. Tangential sections demonstrate that cuniculi occur throughout at least most of the shell, and other shell structures support the conclusion that this form is congeneric with *Parafusulina wordensis* Dunbar and Skinner, 1931, the genotype of *Parafusulina* Dunbar and Skinner. *Parafusulina* ranges in America from the upper part of the Wolfcampian series to the upper part of the middle Guadalupian series. Its stratigraphic range in the Eastern Hemisphere is not well known, but it may be similar to that in America. *Parafusulina wanneri* does not seem highly advanced for the genus. It probably is Leonardian in age.

Specimens of *Parafusulina wanneri* compose a large part of several of the samples studied. In parts of some of the samples, specimens of this form are concentrated in layers several inches thick and most of these specimens are oriented in the same direction. Also, a majority of the specimens are oriented in the same direction in other large limestone samples that are composed almost entirely of shells of this form. The photograph of one of Schubert's samples from Lassi Creek shows that many of the specimens are oriented in the same direction. The slide with the holotype illustrated by Schubert shows seven specimens oriented in about the same direction. Furthermore, the sample of limestone illustrated by Schubert from between Kapan and Pene contains abundant specimens of *Schwagerina? molengraaffi* (Schubert) that are oriented more or less parallel. All of these samples are composed almost entirely of limestone and probably they were not deposited immediately adjacent to land areas. The parallel orientation of the shells suggests that the fusulinids lived in an area of strong currents possibly resulting from the constrictions of oceanic currents between adjacent islands then existing in that border region of the Indian Ocean.

As indicated above, the collections available to me have representatives of only two species, both of which are described and illustrated below. In order, however, that all of the fusulinids of Timor may be summarized here, I am reproducing some of Schubert's illustrations and am including brief descriptions and discussions of his other species.

SYSTEMATIC DESCRIPTIONS

Family FUSULINIDAE Möller
Subfamily SCHWAGERININAE Dunbar and Henbest
PALAEOFUSULINA WEBERI (Schubert)
Plate 34, figures 4, 15

Fusulina weberi SCHUBERT, 1915, Paläontologie von Timor, Lief. 2, pp. 57, 58, pl. 40, figs. 3, 4; pl. 41, fig. 6.

The shell is minute and contains only four to five volutions. Although Schubert did not illustrate a perfectly oriented axial section, the specimen illustrated by figure 4 on his plate 40, here selected as the holotype, seems to be nearly centered. It is one of the largest specimens illustrated and is about 2 mm. long and 0.9 mm. wide. The polar ends seem somewhat rounded. The shell is tightly coiled in the inner one or two volutions, but the outer two volutions are inflated. The first volution is almost spherical in shape. The second and third volutions are elongate fusiform. The fourth volution has the mature shape of the shell.

The proloculus is relatively small and spherical. The septa and spirotheca are exceedingly thin and seem to be composed of a single dense layer. The septa are narrowly fluted, and the fluting extends completely to the tops of the chambers. There are at least 26 septa in the fifth volution of one specimen. A tunnel cannot be identified in the illustrated specimens. There seemingly are no axial fillings.

The very thin walls and highly fluted septa resemble the walls and septa of some of the paratypes of *Palaeofusulina prisca*

Deprat, the genotype of *Palaeofusulina* Deprat. Some of Deprat's illustrations of *P. prisca* evidently are retouched photographs, and the thick spirotheca shown in some of them seems to have been erroneously drawn. All of Colani's specimens (1924) of the genotype species (*Fusulina pseudo-prisca* Colani, 1924, substitute name for homonym *Fusulina prisca* (Deprat), 1913 [not *Fusulina prisca* Möller, 1878]) show a spirothecal structure similar to that of *P. weberi*. In some general respects, *P. weberi* resembles Middle Pennsylvanian (upper Moscovian) *Fusulina* in that it has closely fluted septa and a thin wall. However, the walls of upper Middle Pennsylvanian fusulinids are considerably thicker than the wall of *P. weberi* and their structures probably are entirely different.

Schubert compared *Palaeofusulina weberi* with *Fusulina subtilis* Schellwien, 1908, from the Permian of the Timan Mountains of Arctic Russia. The latter form has a thick kerothecal wall and, beyond a doubt, is not congeneric with *P. weberi*.

Occurrence.—The holotype and common paratypes of *Palaeofusulina weberi* are from east of Pualaca, Portuguese Timor. Schubert stated that other specimens of this form are from Nai Neo, on the north slope of Aubeon. At both places they are associated with a *Schwagerina* referred by Schubert to *Fusulina granum-avenae* Roemer. *P. weberi* is Permian in age and probably early Permian.

Repository.—All of the type specimens are deposited with the Geological and Palaeontological Institute of the University of Bonn.

SCHWAGERINA BROUWERI Thompson, n. sp.
Plate 34, figures 4(?), 5–14;
Plate 35, figure 9

(?) *Fusulina granum-avenae* SCHUBERT [part], 1915, Paläontologie von Timor, Lief. 2, p. 53, pl. 41, fig. 6. [*Not* pl. 39, fig. 1; pl. 41, fig. 5.]

The shell is small and elongate fusiform. It has pointed poles, slightly shifting axis of coiling, and low lateral slopes. The larger specimens of four and one-half to five volutions measure 5.1 to 6.4 mm. long and 1.5 to 2.0 mm. wide, giving form ratios of 3.0 to 3.4. The shell first develops greatly extended polar areas in the fourth volution. The form ratios of the first to the fourth volution of the holotype are 2.5, 3.2, 3.1, and 4.1, respectively.

The proloculus is spherical and has an outside diameter of 191 to 315μ, averaging 246μ for five specimens. The chambers are low in the first one or two volutions, and rapidly increase in height from the second to the fifth volution. The average heights of the chambers in the first to the fifth volution of seven specimens are 70, 112, 190, 295, and 335μ, respectively.

The spirotheca is thick and coarsely alveolar, but the proloculus wall is thick and structureless. The average thicknesses of the spirotheca in the first to the fifth volution of seven specimens are 28, 35, 50, 79, and 91μ, respectively. The spirotheca is of about the same thickness in the central quarter of the shell, but it thins rapidly in the polar area.

The septa are fluted throughout their length and show strong fluting even where the tectum passes through the spirotheca. Closed chamberlets are more than half the height of the chambers. The average septal counts of the first to the fifth volution of two specimens are 13, 22, 25, 30, and 23, respectively.

The tunnel is low and relatively broad and its path is irregular. The chomata are narrow and seem to be absent in the center of the chambers of the outer volutions. The tunnel does not seem to be of the same width in corresponding parts of all specimens. The tunnel angles of several specimens are about 42 degrees in the third volution, 40 to 48 degrees in the fourth volution, and 59 to 62 degrees in the fifth volution.

Remarks.—*Schwagerina brouweri* probably was included by Schubert in the form he described as *Fusulina granum-avenae*. Roemer's type specimens of *F. granum-avenae* are from Sumatra, but they have not been adequately illustrated. Schubert's specimens from Netherlands Timor were not figured. Schubert stated that rare specimens are associated with abundant specimens of *Parafusulina* [*Fusulina*] *wanneri* at Boewan Creek near Niki-Niki. These rare specimens possibly are conspecific with the types of *S. brouweri*. The specimen illustrated by Schubert from east of Pualaca, Portuguese Timor, resembles the type speci-

mens of *S. brouweri*, and they may be conspecific.

Occurrence.—*Schwagerina brouweri* is represented by sparse specimens among very abundant *Parafusulina wanneri* (Schubert) in red to pinkish limestone from Boenoe River easterly from Niki-Niki, Netherlands Timor. This locality is near Basleo and is in the same general area from which the famous and well-known Basleo fauna was described by Haniel (1915) and others. This is also the general locality from which the Tae Wei fauna was described by Oyens (1938). Several ages of fossils have been reported from this general region. This form possibly occurs east of Pualaca, Portuguese Timor.

Repository.—The holotype and illustrated paratypes of *Schwagerina brouweri*, n. sp., are deposited with the Geological Institute, University of Amsterdam.

SCHWAGERINA? MOLENGRAAFFI (Schubert)
Plate 34, figures 1–3

Fusulina molengraaffi SCHUBERT, 1915, Paläontologie von Timor, Lief. 2, pp. 55–57, pl. 39, fig. 3, pl. 40, fig. 2, pl. 41, figs. 2–4.

Schwagerina? molengraaffi is represented by numerous specimens in the collections studied by Schubert. He illustrated a slab of limestone that contains several dozen specimens on its surface. The shell is rather small, and mature specimens of about six to seven volutions measure at least 5.2 to 6.8 mm. long and 0.9 to 2.1 mm. wide. The shell is elongate subcylindrical with blunt poles and flat lateral surfaces in the central half. The first two volutions are short and robust, the third and fourth volutions are fusiform with sharply pointed poles, and the mature shape of the shell begins with the fifth volution.

TABLE OF MEASUREMENTS OF SCHWAGERINA BROUWERI
(in millimeters)

Specimens	L.	W.	No. vols.	Diam. prol.	Height of volutions				
					1	2	3	4	5
1	—	2.33	5	.191	.098	.149	.228	.385	.362
2	6.40	1.86	4½	—	.063	.126	.186	.276	.373
3	—	1.63	4	.277	.058	.100	.203	.320	—
4	—	1.54	4½	.315	.077	.117	.196	.350	.405
5	5.13	1.71	4½	.193	.047	.079	.114	.221	.310
6	—	1.98	5	.256	.077	.112	.184	.267	.268
7	6.06	1.85	5	—	—	.102	.151	.242	.292

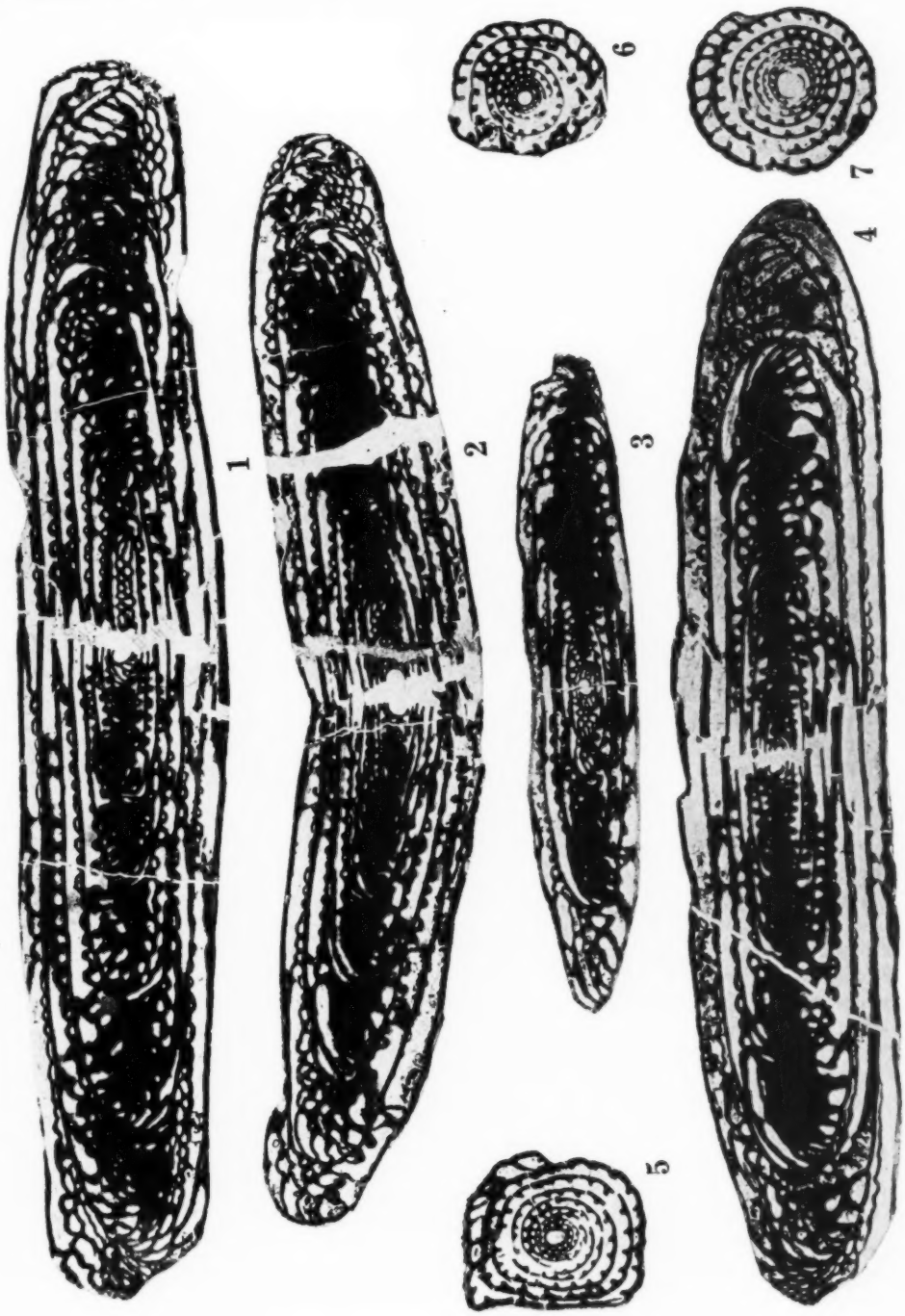
Specimen	Thickness of spirotheca				
	1	2	3	4	5
1	.030	.035	.054	.086	.084
2	—	.033	.047	.065	.090
3	—	.035	.054	.082	—
4	.026	.035	.056	.089	—
5	—	.035	.035	.070	.100
6	.028	.037	.056	.093	—
7	—	—	.047	.065	.088

(Specimens 1, 3, 4, 5, 7, and 2 are illustrated by figures *14*, *13*, *11*, *5*, and *8*, Plate 34, and figure *9* Plate 35, respectively.)

EXPLANATION OF PLATE 36

All illustrations on this plate are magnified ×10.

FIGS. *1–7*—*Parafusulina wanneri* (Schubert). *1–4*, Axial sections and *5–7*, sagittal sections. All from limestone blocks on Boenoe River east of Niki-Niki, Netherlands Timor. (p. 189)



Thompson, Permian Fusulinids

The proloculus is large and spherical. Its outside diameter measures about 248μ. The first two to three volutions are tightly coiled and the chambers increase rather uniformly in height. The chambers of the sixth volution are about 280μ high.

The spirotheca is thick and seems to be composed of a tectum and a thick keriotheca. The septal furrows are distinctly defined in the central part of the shell and are very deep in the polar regions, giving the surface of the spirotheca a pronounced scalloped pattern.

The septa are closely spaced. Schubert gave the septal counts of the first to the sixth volutions of two specimens as 9 and 10, 12 and 14, 14 and 16, 14 and 15, 15, and 17, respectively. The septal counts of the first to the sixth volution of the illustrated sagittal section are about 10, 14, 15, 14, 16, and 18, respectively. The septa are fluted throughout the length of the shell. However, the fluting in the central part seems to be confined to the extreme lower margins of the septa. In the polar regions, the fluting forms closed chamberlets about half the height of the septa.

The tunnel is low and broad. Low chomata can be observed in the inner few volutions. If axial fillings are present, they are not thick.

Remarks.—*Schwagerina? molengraaffi* resembles *Parafusulina wanneri* (Schubert) in general shape. However, the former species is much smaller, has lower septal fluting, seemingly does not have axial fillings or cuniculi, and has a larger form ratio at maturity.

Schubert compared *Schwagerina molengraaffi* with *Fusulina incisa* Schellwien, 1898, from the Karnic Alps. Schellwien's illustrations of *F. incisa* are drawings, but it seems probable that these forms are congeneric. *F. incisa* is more inflated, has more highly fluted septa, and probably has a thicker spirotheca.

Occurrence.—*Schwagerina? molengraaffi* is very abundant in reddish to reddish-brown limestone on the road between Kapan and Pene, and at *Fusulina* Mountain between Kapan and Akbidi-Hügeln.

Repository.—The types of this form are deposited at the Technical High School of Delft.

SCHWAGERINA sp.
Plate 35, figures 7, 8

Fusulina granum-avenae [part] SCHUBERT, 1915, Paläontologie von Timor, Lief. 2, p. 53, pl. 39, fig. 1, pl. 41, fig. 5. [*Not* pl. 41, fig. 6]

Schubert illustrated a sample of limestone collected from between Poetain and Besikama-Ebene that contains abundant specimens of a small form that is fusiform and has rather sharply pointed poles. Seemingly only one species is present in this sample. Schubert also illustrated an oblique axial section from the same locality which contains six volutions and measures about 3.0 mm. in diameter. The septa are narrowly fluted throughout the length of the shell and the fluting extends completely to the tops of the chambers. The spirotheca is of moderate thickness for this genus. Axial fillings seem to be massive, for they can be observed even in this strongly oblique section.

Schubert referred this form to *Fusulina granum-avenae* Roemer, originally described from Sumatra. Roemer's types of *Fusulina granum-avenae* were illustrated by outline drawings, and his description is too brief. If the specimen from Sumatra illustrated by Staff (1910) as *Fusulina granum-avenae* is conspecific with the form described by Roemer, the Timor specimens are not conspecific with Roemer's form. Some of the specimens from Netherlands Timor referred by Schubert to *Fusulina granum-avenae* may be referable to *Schwagerina brouweri*, n. sp.

Occurrence.—Schubert's collections of this form came from between Poetain and Besikama-Ebene, Netherlands Timor. Possibly conspecific specimens came from east of Pualaca, Portuguese Timor.

Repository.—Schubert's specimens are deposited at the Technical High School of Delft.

PARAFUSULINA WANNERI (Schubert)
Plate 35, figures 1–6;
Plate 36, figures 1–7

Fusulina wanneri SCHUBERT, 1915, Paläontologie von Timor, Lief. 2, pp. 54, 55, pl. 39, fig. 2, pl. 40, fig. 1; pl. 41, figs. 1, 7.

The shell is large, highly elongate subcylindrical, with straight to slightly curving axis of coiling, uniform to parallel lateral

TABLE OF MEASUREMENTS OF PARAFUSULINA WANNERI
(in millimeters)

Specimen	L.	W.	No. vols.	Diam. Prol.	Height of volutions							
					1	2	3	4	5	6	7	8
1	18.17	2.92	8	.303	.065	.070	.119	.175	.160	.235	.268	.280
2	15.61	2.92	8	.205	.065	.075	.126	.163	.186	.235	.315	.268
3	14.70	2.33	7½	.219	.033	.084	.097	.103	.135	.163	.223	.268
4	15.61	2.63	8	.303	.056	.070	.093	.110	.135	.190	.233	.317
5	—	2.26	6½	.280	.072	.091	.105	.147	.154	.242	.233	—
6	—	2.21	7	.202	.049	.061	—	—	.176	.182	.226	—
7	—	2.16	7	.335	.088	.093	.084	.119	.163	.195	.223	—
8	—	2.42	7	.280	.054	.051	.105	.124	.158	.205	.233	—
9	—	2.56	8	.326	.047	.058	.098	.105	.133	.191	.221	.287
10	—	2.68	7	.396	.077	.082	.093	.161	.158	.200	.301	—

TABLE OF MEASUREMENTS OF PARAFUSULINA WANNERI—(*continued*)
(in millimeters)

Specimen	Thickness of spirotheca									Form ratio of volutions							
	0	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
1	.028	—	.028	.047	.042	.056	.075	.089	.093	2.7	4.0	4.8	6.0	6.7	7.0	7.0	6.2
2	.019	—	—	.033	.040	.054	.063	.070	.070	2.6	3.7	5.0	5.4	6.2	6.3	5.8	5.3
3	—	—	—	—	.033	.044	.042	.054	.084	1.6	1.8	4.6	5.4	5.5	5.2	5.5	6.3
4	.025	—	.035	.028	.035	.037	.058	.070	.075	3.5	5.0	5.3	6.1	6.0	6.3	6.0	6.0
5	—	.028	.047	.042	.047	.061	.075	.088	—	3.5	5.0	5.2	5.8	6.2	5.8	—	—
6	.026	—	—	—	.030	.047	.061	.077	—	—	—	—	—	—	—	—	—
7	.037	.019	.026	.035	.040	.056	.058	.077	—	—	—	—	—	—	—	—	—
8	.026	—	.026	.040	.042	.056	.065	.093	—	—	—	—	—	—	—	—	—
9	—	—	.026	.030	.033	.044	.056	.082	.086	—	—	—	—	—	—	—	—
10	.023	.019	.023	.033	.042	.047	.075	.091	—	—	—	—	—	—	—	—	—

TABLE OF MEASUREMENTS OF PARAFUSULINIA WANNERI—(*continued*)
(in millimeters)

Specimen	Septal Count								Tunnel angles (degrees)						
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7
1	—	—	—	—	—	—	—	—	—	—	40	68	76	62	56
2	—	—	—	—	—	—	—	—	—	45	—	60	—	73	80
3	—	—	—	—	—	—	—	—	—	—	—	42	55	80	—
4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
5	—	—	—	—	—	—	—	—	—	45	45	64	80	60	—
6	11	16	18	20	21	22	—	—	—	—	—	—	—	—	—
8	9	19	18	20	18	22	25	—	—	—	—	—	—	—	—
8	13	18	16	21	22	22	24	—	—	—	—	—	—	—	—
9	12	18	15	16	17	21	22	24	—	—	—	—	—	—	—
10	11	19	20	20	21	24	27	—	—	—	—	—	—	—	—

(Specimens 6, 7, 8, 1, 2, 4, 9, 10 are illustrated by figures *5*, *6*, *3*, Plate 35, and figures *1*, *4*, *2*, *5*, *7* Plate 36, respectively.)

surfaces, and blunt polar ends. Most specimens have unusually uniform to flat lateral slopes, and mature shells are cylindrical throughout their central areas. Mature shells of seven to eight volutions are 14.7 to 18.2 mm. long and 2.3 to 2.9 mm. wide, giving form ratios of 5.3 to 6.3. The inner two to three volutions are fusiform with sharply pointed poles. Beyond the third volution, the poles rapidly become blunt to rounded. The average form ratios of the first to eighth volution of five specimens are

2.8, 3.9, 5.0, 5.7, 6.1, 6.1, 6.1, and 6.0, respectively. In most specimens, the greatest relative length is attained in about the sixth volution; the shell becomes relatively shorter as maturity is approached.

The proloculi of most specimens are nearly spherical but in some they are irregular and seem deformed. Outside diameters measure 200 to 400μ, averaging 285μ for ten specimens. The shell expands regularly and somewhat uniformly for the first seven volutions. The last volution of many specimens of eight volutions is more tightly coiled and the chambers are accordingly lower. The average heights of the chambers in the first to the eighth volution of ten specimens are 54, 74, 102, 134, 159, 204, 248, and 284μ, respectively. The chambers are of about the same height in the central part of the shell, but they become higher immediately adjacent to the polar region.

The spirotheca is thin, but it is relatively somewhat thicker than in many species of *Parafusulina*. Alveoli are coarse in the lower part of the spirotheca but are not clearly visible in the upper area immediately below the tectum. The wall of the proloculus is about 25 microns thick and structureless, except for the aperture. The average thicknesses of the spirotheca in the first to the eighth volution of ten specimens are about 22, 30, 36, 38, 50, 63, 79, and 82μ, respectively. The spirotheca is of about the same thickness throughout the central area of the shell but decreases in thickness in the polar regions.

The septa are closely spaced and composed of a tectum, a thicker distinct layer on the posterior side (probably the pycnotheca), and a distinct wedge-shaped extension of the keriotheca down the anterior side of the tectum. They are strongly fluted in their lower halves but become almost plain above. In the end zones the salients of the fluting extend forward as much as the width of the following two chambers. Cuniculi are distinct in at least the outer five volutions of mature shells, but they are narrow and low. Septal pores are abundant and closely spaced. The average septal counts of the first to the eighth volution of five specimens are 11, 18, 17, 19, 20, 22, 24, and 24, respectively.

The tunnel is low and broad. Chomata are present in all volutions where a tunnel is developed, but they are narrow. Axial fillings are heavy and are present in all volutions that have a distinct tunnel. The average tunnel angles of the second to seventh volution of four specimens are about 45, 42, 59, 70, 69, and 64 degrees, respectively. Many of the shells are crushed or broken and offset along the tunnel, and measurements of the tunnel angles are only close approximations.

Remarks.—Several features of the shell structure of *Parafusulina wanneri* indicate that this species is a primitive form of the genus. Its cuniculi are low and narrow, it has a rather thick spirotheca, and its septa are closely fluted only in their lower regions. This form resembles *P. kattaensis* (Schwager) from the Lower Productus limestone of the Salt Range of India in several respects. They can be distinguished without difficulty, however, for *P. wanneri* has more volutions at maturity, thinner spirotheca and a smaller shell for corresponding volutions, but is larger at maturity. Seemingly the cuniculi of *P. kattaensis* are broader than are those of *P. wanneri*. Although the evolution within the genus *Parafusulina* is not known with certainty, especially in the Eastern Hemisphere, the cunicular development seems to indicate that *P. wanneri* is the more primitive. However, the size and spirothecal thickness indicates that *P. kattaensis* is the more primitive. Both forms are rather small for the genus, and their narrow cuniculi suggest that they are both from the lower part of the Zone of *Parafusulina*; that is, they probably are of Leonardian rather than Guadalupian age.

Parafusulina caracorumensis (Merla) from Karakorum resembles *P. wanneri* in several respects. Some of the major points of difference seem to relate to size and septal counts. The Timoran form is larger but has a smaller septal count. Silvestri (1935) described *P. caracorumensis* as *Fusulina wanneri*. Reichel (1940) considered them to be synonymous.

Occurrence.—*Schwagerina brouweri*, n. sp., is the only fusulinid associated with *Parafusulina wanneri* in the five large samples of reddish to pinkish limestone collected from Boenoe River east of Niki-Niki. The holotype and abundant associated paratypes of *P. wanneri* came from the spring area of Lassi Creek (Noil Lassi) between Bele and Niki-Niki. Other paratypes were reported

by Schubert from the following localities in Netherlands Timor:

Moetis Creek between Ofoe and Bele.
Along the route between Bele and Toi.
On Boewan Creek near Niki-Niki.
On the road from Fatu Ocenoes toward Bonabaat.
From terrace gravels of Toeke Creek.
From stream gravel of Lassi Creek.
Between Maubesi and Soefa.
Near *Fusulina* Mountain east of Kapan.

Schubert also indentified *P. wanneri* from the base of Bissori, northwest of Pualaca, Portuguese Timor.

Repository.—The holotype and part of the paratypes of *Parafusulina wanneri* are from collections made by the Molengraff expedition of 1911 and were deposited by Schubert in the Technical High School of Delft. Others from the Wanner expedition of 1909 and 1911 and the Weber expedition of 1911 were deposited with the Geological and Paleontological Institute of the University of Bonn. All specimens illustrated for the first time in this report are in the Geological Institute of the University of Amsterdam.

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TERTIARY CORALLINE ALGAE FROM THE DUTCH EAST INDIES

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ABSTRACT—Several species of algae are described from beds ranging in age from Eocene to Miocene. They belong to the genera *Archaeolithothamnium*, *Lithothamnium*, *Lithophyllum*, *Lithoporella*, *Amphiroa*, *Corallina*, and *Jania*.

Species described as new are: *Lithothamnium borneoense*, *L. nanosporum*. *Mesophyllum javaense*, *Lithophyllum parricellum*, and *Corallina delicatula*.

INTRODUCTION

STUDIES of the limestones of the Netherlands East Indies to date have been concerned largely with the so-called "large Foraminifera" represented by such genera as *Camerina*, *Discocyclina*, *Lepidocyclina*, and *Miogypsina*. The "letter stage subdivision" for the regional stratigraphy was erected by Umbgrove and Van der Vlerk based on the stratigraphical range of these genera.

About 1933 the major oil companies began to make a systematic stratigraphic study of the region including investigation of small Foraminifera. In the course of this work, numerous calcareous algae were found. Some of these were described by Lignac-Grutterink in 1943. The present study is based on a small collection of specimens and slides obtained by L. W. LeRoy from the Eocene and Miocene of eastern Borneo and western Java.

The collection consists of only about 10 specimens and 21 slides, but some specimens are so crowded with algal fragments that a single slide shows remains of several genera and a number of species. The material is beautifully preserved.

CLASSIFICATION OF THE CORALLINE ALGAE

The classification (Lemoine, 1939, p. 38) in general use is given below. It includes all the genera considered here as well as some other closely related ones.

Class Rodophyta
Family CORALLINACEAE
Subfamily MELOBESIEAE
Archaeolithothamnium
Mesophyllum
Lithophyllum
Lithoporella
Lithothamnium
Porolithon
Subfamily CORALLINEAE
Amphiroa
Arthrocardia
Corallina
Jania

DESCRIPTIONS

Subfamily MELOBESIEAE

Genus ARCHAEOLITHOTHAMNIUM Rothpletz

This genus is represented in our collections by only a few small fragments of crusts. They consist of tissue without any conceptacles. The appearance of the tissue and the cell dimensions (16–27μ by 8–13μ) suggest that they belong to *Archaeolithothamnium affine* Howe. This species was reported from a number of localities in Borneo by Lignac-Grutterink (1943). Our specimens are too fragmentary to warrant description and illustration. They are from the Miocene of West Java.

Genus LITHOTHAMNIUM (Philippi)

This genus is represented by a number of fragments of tissue which appear to belong mainly to encrusting forms.

LITHOTHAMNIUM BORNEOENSE Johnson and Ferris, n. sp.
Plate 37, figure 1

Thallus: Forms a thin crust on large Foraminifera and other objects, including other algae.

Hypothallus: Poorly developed; consists of several rows of irregular and poorly arranged cells. These average slightly smaller than those of the perithallus.

Perithallus: Usually consists of 6 to 14 rows of cells. Both the cells and the rows are frequently irregular. Cells 0.014 to 0.018 mm. long and 0.009 to 0.012 mm. wide.

Conceptacles: Unknown.

Age: Eocene.

Locality: South of Makakan, East Borneo.

Remarks: Among known Eocene species *L. laminosum* Howe most clearly resembles this form which differs in having shorter and more irregular cells in the perithallus.

Type: Slide 859, Johnson collection, Colorado School of Mines.

LITHOTHAMNIUM cf. MINAE Lemoine
Plate 37, figure 3

Lithothamnium minae LEMOINE, 1939, p. 69; fig. 29, p. 79.

Thallus: Forms crusts up to 4 mm. thick.

Hypothallus: Poorly developed or absent on the fragments studied.

Perithallus: A compact tissue of layers of very fine cells. Layers not conspicuous and tissue appears even and homogeneous. Cells small, usually wider than high, and quite uniform, measuring from 0.006 to 0.007 mm. wide and from 0.004 to 0.006 mm. high.

Conceptacles: Small, rounded; measuring 0.125 to 0.175 mm. long and 0.065 to 0.085 mm. high. Some show several apertures in roof.

Age: Miocene, probably Upper Miocene.

Locality: Tjijarian Bridge, West Java.

Remarks: In growth habit, texture, cell size, and size of conceptacles, this form is similar to *L. minae* which Mme. Lemoine described from the middle Eocene and Oligocene of Algeria. It differs only by lacking some rounded cells recognized by Lemoine in the Algerian specimens.

LITHOTHAMNIUM NANOSPORNUM
Johnson and Farris, n. sp.
Plate 37, figure 2

Thallus: A thick irregular crust with a strongly developed hypothallus and a much thinner perithallus.

Hypothallus: Irregularly arranged rounded cells measuring 0.006 to 0.011 mm. by 0.006 to 0.009 mm.

Perithallus: Composed of rather regular vertical rows of rectangular cells 0.008 to 0.014 mm. long and 0.009 to 0.014 wide. Walls thick between vertical cell rows, thin cross partitions.

Conceptacles: Small but variable, measuring 0.068 to 0.192 mm. long, and 0.035 to 0.108 mm. wide.

Age: Eocene.

Locality: East Borneo.

Remarks: This species is unusual in the thick irregular hypothallus, the small cells, and the small conceptacles.

Type: Slide 1234, Johnson collection, Colorado School of Mines.

Genus MESOPHYLLUM Lemoine

This genus, so common among collections of Miocene coralline algae from southern Europe, the Mediterranean and Caribbean regions, is represented in the collection by only a few fragments of tissue. All appear to belong to one species. *Mesophyllum* is intermediate structurally between *Lithothamnium* and *Lithophyllum*, having conceptacles similar to the first and tissue similar to the second.

MESOPHYLLUM JAVAENSE
Johnson and Ferris, n. sp.
Plate 38, figures 1 and 2

A small nodular form with slight mammillary protuberances. One specimen shows a protuberance 0.6 cm. long.

Hypothallus: Poorly developed or missing on the slides studied. Contains small cells approximately same size as those of the perithallus.

Perithallus: Composed of irregular layers

EXPLANATION OF PLATE 37

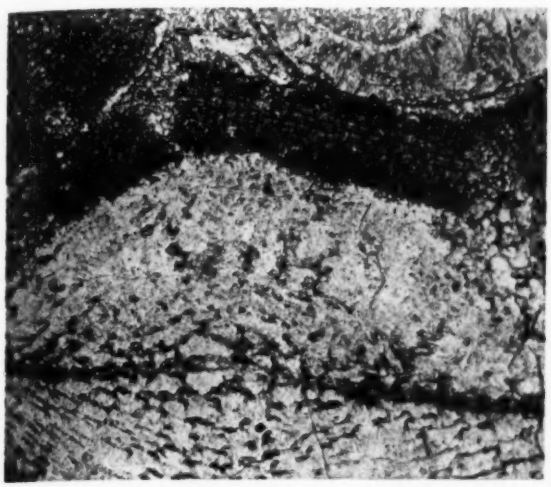
FIG. *1*—*Lithothamnium borneoense* Johnson and Ferris n. sp., encrusting an orbitoid foraminifer. (*Discocyclina?*) (×125). East Borneo. (p. 193)

2—*Lithothamnium nanospornum* Johnson and Ferris n. sp. (×75). A fragment of tissue with scars of several conceptacles. On top is a thallus of *Lithoporella* (*M.*) *melobesioides* Foslie. (p. 194)

3—*Lithothamnium* cf. *minae* Lemoine (×75). A fragment of tissue with two rows of conceptacles. (p. 194)

4—*Lithoporella* (*Melobesia*) *melobesioides* Foslie (×75). Several thalles one above the other. (p. 196)

5—*Lithoporella* (*Melobesia*) *melobesioides* Foslie (×75). A typical thallus consisting of a single row of cells. (p. 196)



1

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2

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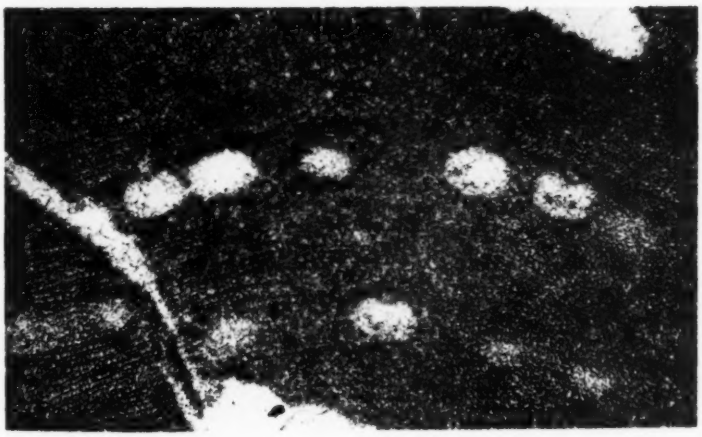
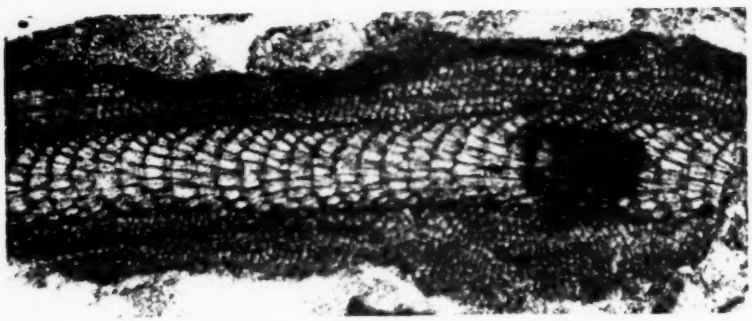


3

Johnson and Ferris, Tertiary Algae

1

2



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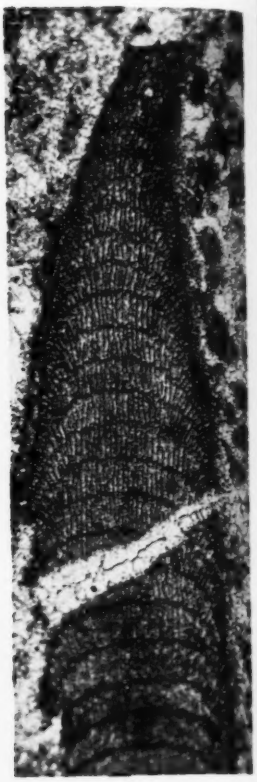

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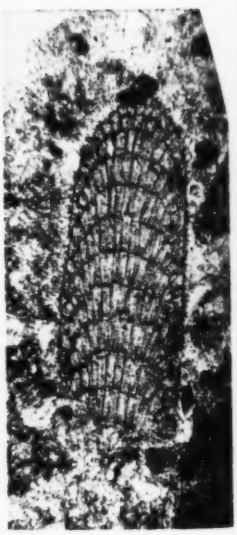

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Johnson and Ferris, Tertiary Algae

of very small cells. Each layer composed of a number of rows of cells with thick, dark lines between the layers giving a zoned appearance to the tissue. Cells approximately square, measuring 0.0054 to 0.008 mm.

Conceptacle cavity observed in one specimen; measures 0.0175 by 0.0125 mm.

Age: Miocene, probably Upper Miocene.

Locality: West Java at Tjijarian Bridge.

Remarks: This is an exceptionally fine-celled form. The most similar known Miocene species is *M. gignou* Lemoine from Algeria which differs by lacking protuberances and having much larger cells in the hypothallus. The growth habit and small size of the cells in *M. javaense* suggest *M. curtum* Lemoine, also from the Miocene of Algeria, but differs from it in having much smaller conceptacles.

Type: Slide 856, Johnson collection, Colorado School of Mines.

Genus Lithophyllum

This genus is more abundantly represented in the collection than any other. The specimens included both branching and encrusting forms, but most of them are only small pieces of tissue. Only a few are large enough or sufficiently complete to warrant description. Several other species are present.

Lithophyllum aff. prelichenoides Lemoine

Plate 38, figure 3

Lithophyllum prelichenoides Lemoine, 1939, p. 99; figs. 65, 66, p. 107.

Thallus: Probably foliaceous or lamellose with well developed hypothallus and rather slender perithallus.

Hypothallus: Curved rows of cells longer than wide, measuring 0.012 to 0.045 mm. long (average 0.020–0.040) and 0.008 to 0.0216 mm. wide.

Perithallus: Usually less than 8 rows of cells thick. Cells measure 0.0099 to 0.0153 mm. long (average 0.014 mm.) by 0.0099 to 0.014 mm. wide (average 0.011).

Conceptacles: None observed.

Age: Miocene.

Locality: South Makakan, East Borneo.

Remarks: In appearance these specimens suggest *L. prelichenoides* Lemoine which is abundant in the Mediterranean region in beds ranging from Lower Miocene to Pliocene. The cell size falls within the limits observed in that species, but the average size is slightly smaller. However, without data on the conceptacles, it does not seem wise to propose a new species.

Lithophyllum parvicellum Johnson and Ferris, n. sp.

Plate 39, figure 3

Thallus: Probably encrusting, possibly foliaceous, with a well developed hypothallus and a medium thick perithallus.

Hypothallus: Gently tapering. Cells have thick walls, measuring 0.009 to 0.0135 mm. long and 0.0099 to 0.0108 wide.

Perithallus: Rectangular cells 0.01 to 0.0145 mm. long and 0.008 to 0.01 wide.

Conceptacles: Unknown.

Age: Miocene.

Locality: West Java near Tjijarian Bridge.

Remarks: This species has smaller cell dimensions than any previously recorded Oligocene or Miocene *Lithophyllum*.

Type: Slide 856, Johnson collection, Colorado School of Mines.

Genus Lithoporella

This genus shows the simplest structure of any of the Melobesieae. It also develops the largest cells and conceptacles.

A number of names have been applied to the genus. Madame Lemoine uses the name *Melobesia*, but most recent writers follow Foslie's use of *Lithoporella*.

Explanation of Plate 38

Figs. *1, 2*—*Mesophyllum javaense* Ferris n. sp. (×75). Tissue of irregular layers, and one conceptacle. *2*, Same as Figure *1* (×125), showing detail of tissue and conceptacle. (p. 194)

3—*Lithophyllum* aff. *prelichenoides* Lemoine (×75). Well developed hypothallus of curved cell rows with perithallus on both sides of horizontal layer of cells. (p. 195)

4—*Amphiroa* sp.? (×75). A nearly complete branch. (p. 198)

5—*Jania* sp.? (×70). Upper portion of a branch. (p. 198)

LITHOPORELLA (MELOBESIA) MELOBESIOIDES Foslie

Plate 37, figures 4, 5; Plate 39, figure 2

Lithoporella (*Mastophora*) *melobesioides* FOSLIE (Weber van Bosse and Foslie, 1904, pp. 73–77, figs. 30–32.

Melobesia (*Lithoporella*) *melobesioides* FOSLIE (Lemoine, 1939, pp. 108–110, figs. 78, 79)

Lithoporella melobesioides (FOSLIE) Foslie (Lignac-Grutterink, 1943, pp. 292–293, pl. 2, fig. 8).

Thallus: Thin, often less than 0.1 mm. thick, growing attached to other coralline algae, corals, or other objects. Several specimens show a number of thalles superimposed on each other; a few were interstratified with other algae.

Commonly each thallus is formed of a single layer of cells, usually in an undifferentiated row, although a few specimens are composed of several (2–3) rows of cells.

The cells are usually rectangular and larger than in most species of *Melobesia*. They vary greatly in size in the same specimen as the rows of cells taper and swell. The dimensions of a number of specimens measured are listed below:

No.	Length (mm.)	Width (mm.)	Age	Locality
858a	0.036–0.046	0.019–0.029	Miocene	East Borneo
858b	0.024–0.034	0.016–0.024	Miocene	East Borneo
858c	0.029–0.046	0.021–0.030	Miocene	East Borneo
1233	0.041–0.043	0.019–0.027	Miocene	East Borneo
1233 another layer	0.026–0.029	0.016–0.021	Miocene	East Borneo

All of the Miocene specimens fall within the same range of cell dimensions and are considered to represent a single species. The specimen shown on plate 39, figure 2 is interesting because the normal single row of long cells changes laterally into a layer consisting of several rows of nearly square cells.

Similar small, nearly square cells also fill or partially fill old conceptacle scars.

Conceptacles: Several of the specimens showed conceptacles and scars left by conceptacles. The conceptacles were about two-thirds as high as wide, but the scars covered by later growths all had suffered considerable solution so they are usually much wider than high. Specimens measured show the following dimensions: 0.20 by 0.30 mm., 0.30 by 0.30 mm., 0.25 by 0.15 mm., 0.40 by 0.10 mm.

Age: Eocene to Recent.

Locality: Borneo.

Remarks: This species is the most abundant form in our collection. It was also described by Lignac-Grutterink from Borneo in rocks ranging in age from Eocene to Pleistocene. She gives measurements of cells from ten specimens, showing extremes of 0.042 to 0.0668 mm. long and 0.014 to 0.0308 mm. wide and remarks on the great variation in size of cells.

Similar material has been described by a number of writers from rocks whose age extends from Lower Eocene to Recent and from such widely scattered areas as the West Indies (Howe, 1919), Algeria (Lemoine, 1939), and the East Indies (Lignac-Grutterink, 1943). Earlier writers attempted to

EXPLANATION OF PLATE 39

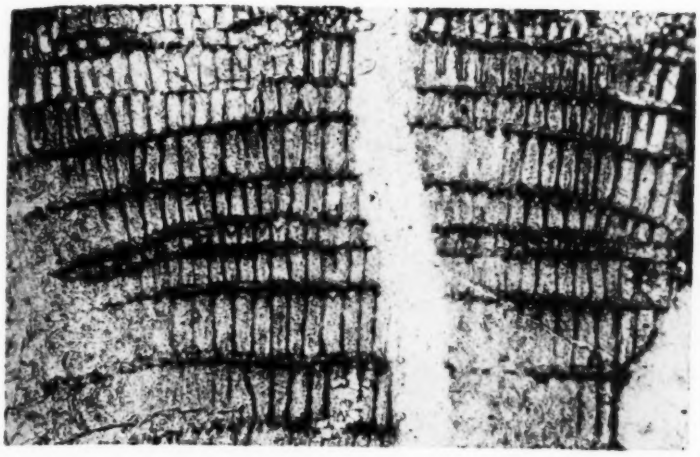
FIG. *1*—*Lithoporella* (*Melobesia*) sp.? (×75). A series of superimposed thalles. (p. 197)

2—*Lithoporella* (*Melobesia*) *melobesioides* Foslie (×75). A series of superimposed irregular thalles, with a conceptacle partly filled with small square cells. Shows layers of long single cells changing laterally into layers composed of several rows of nearly square cells. (p. 196)

3—*Lithophyllum parvicellum* n. sp. (×75). Shows well developed hypothallus with curved rows of cells, and perithallus of long parallel cell rows. (p. 195)

4—*Corallina delicatula* n. sp. (×75). Three connected branch segments with modes between. (p. 197)

5—*Corallina crossmanni* Lemoine (×75). Two rather frayed branch segments and node between. (p. 197)



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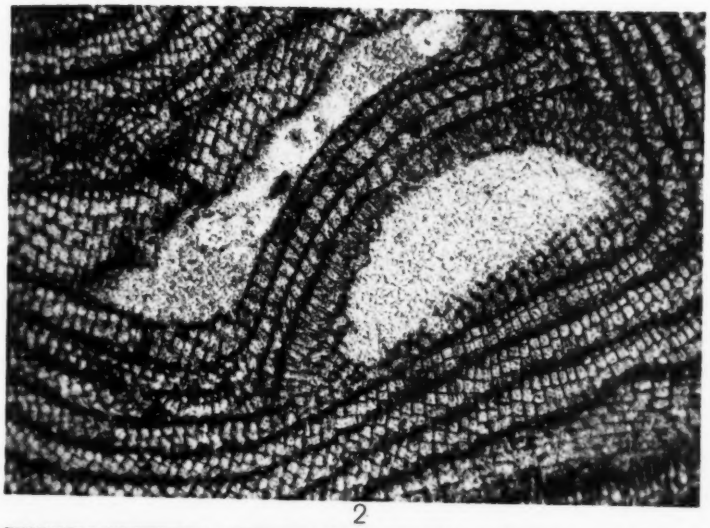

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Johnson and Ferris, Tertiary Algae

assign the fossils to a number of species. Howe (1919, p. 16) pointed out the great variation in size of cell in every specimen studied with all intermediate gradations occurring. The modern specimens show similar variation and fall within the same size range. Howe suggested all be considered as belonging to the same species and this has been done by later writers. Both Lemoine (1939, p. 109) and Lignac-Grutterink (1943, p. 293) not only quote Howe, but also review the abundant material in their collections and conclude that his suggestion should be followed.

It should also be noted that besides the wide range in cell size, there is also a wide variation in size of conceptacles. In the specimens and literature checked, the conceptacles show a range of length from 150μ to 1,000μ and height from 75μ to 350μ, with all intermediate sizes.

Foslie (1904, p. 73) described modern material from the East Indies collected by the Siboga expedition which in appearance and dimensions agrees with our specimens.

LITHOPORELLA (MELOBESIA) sp.?
Plate 39, figure 1

Thallus: Consists of a single row of long rectangular cells. The specimen consists of ten superimposed thalles forming an incrustation on a large foraminifer.

Cells: Rectangular, thick-walled, usually much higher than wide. Measure 0.082 to 0.087 mm. high by 0.028 to 0.038 mm. wide in the longer, thicker rows.

Conceptacles: Unknown.

Age: Eocene.

Locality: S. Makakan, East Borneo.

Remarks: This resembles *L.* (*M.*) *melobesoides* in general appearance and growth habit, but differs in having larger and longer cells. The cells are different from those of any hitherto described Eocene or Oligocene form. The most similar is *L.* (*M.*) *assamica* Rao, but in that form the cells are nearly square while this species has long, relatively narrow cells. However, with only one small sterile specimen, it does not seem advisable to give it a name.

Subfamily CORALLINEAE
Genus CORALLINA (Linnaeus) Lamouroux

CORALLINA DELICATULA
Johnson and Ferris, n. sp.
Plate 39, figure 4

Branches (intergenicula): 0.5 to 0.58 mm. long; consist principally of a medullary filament of rows of long, straight, parallel cells, measuring 0.045 to 0.050 mm. long and 0.006 to 0.008 mm. wide. These are of essentially equal length except for a very narrow row just above and below the node. One piece shows traces of a narrow marginal layer of short, nearly square cells.

Nodes (genicula): 0.15 to 0.165 mm. long. Consist of one zone of long cells.

Branching: Pinnate, as can be seen from the branch emplacements on the ends of the branches.

Conceptacles: Unknown.

Age: Eocene, associated with Foraminifera of the genus *Pellatispira*.

Locality: East Borneo.

Remarks: Only a few Tertiary species of *Corallina* have been described. The only two which are adequately illustrated are *C. grandis* K. S. Rao and *C. crossmanni* Lemoine (in Lignac-Grutterink, 1943). The latter is from Borneo. However, both of these species have much longer branches, formed of longer and wider cells.

Type: Slide 1234, Johnson collection, Colorado School of Mines.

CORALLINA CROSSMANNI Lemoine
Plate 39, figure 5

Corallina crossmanni LEMOINE, 1917, Geol. Soc. France Bull., vol. 7, p. 265.
Corallina crossmanni LIGNAC-GRUTTERINK, 1943, Verk. Geol. Minjb. Gen. Geol. Ser., vol. 13, p. 294.

Branches (intergenicula): 0.42 to 0.55 mm. long. Consist of a medullary filament of rows of long, straight, parallel cells measuring 0.058 to 0.079 mm. long and 0.009 to 0.011 mm. wide. The frayed edges have indications of a row of narrow marginal cells.

Nodes (genicula): About 0.125 mm. long, but not sufficiently well preserved to show the structure.

Conceptacles: Unknown.

Age: Eocene.

Locality: East Borneo.

Remarks: This species is represented in

the collection by only one rather frayed specimen. The general appearance and cell measurements fit the descriptions given by both previous authors.

Genus AMPHIROA Lamouroux
AMPHIROA? sp.?
Plate 38, figure 4

Branches (intergenicula): 0.07 to 0.1 long, gently tapering. Consist of a wide medullary filament built of arched rows of long, straight parallel cells which measure 0.048 to 0.062 mm. long and 0.007 to 0.011 mm. wide. There are 17 to 25 rows of cells in a branch. A well developed marginal layer of small, nearly square cells is present, backed by a zone of longer cells.

Nodes: Unknown.

Conceptacles: Unknown.

Age: Eocene.

Locality: East Borneo.

Remarks: One slide shows six loose, frayed branches of this form. The general appearance suggests the genus *Amphiroa*, while the nearly uniform length of the rows of cells and gently tapering frond suggest the genus *Metagoniolithon*. However, it is impossible to distinguish between these genera without a knowledge of the nodes and conceptacles. This specimen differs considerably from any described Eocene form.

Genus JANIA
JANIA sp.?
Plate 38, figure 5

Branches (intergenicula): Represented by one incomplete fragment about 0.7 mm. long. The medullary filament consists of curving rows of long, straight, rectangular cells measuring 0.047 to 0.07 mm. long by 0.013 to 0.018 mm. wide. There are 10 of these rows on the specimen. A well developed marginal layer of small, rectangular cells is present.

Nodes: Not present.

Conceptacles: Unknown.

Age: Eocene.

Locality:? S. Makakan, East Borneo.

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THE MAQUOKETA COQUINA OF CEPHALOPODS

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ABSTRACT—At one or two localities in northeastern Iowa, the Elgin member of the Maquoketa shale contains *Dolorthoceras sociale* in extreme abundance. A few other marine invertebrates (including additional nautiloids) occur in direct association. It is concluded that these cephalopods were concentrated by local currents and eddies and that wave action in shallow water accounts for their telescoping into one another and for their random orientation. Comparable occurrences in other strata are cited. A new species of *Beloitoceras* and one of *Probillingsites* are illustrated and are described in an appendix.

SOME parts of the Ordovician Maquoketa shale of the Upper Mississippi Valley are abundantly fossiliferous. The fauna consists of a large variety of marine invertebrates, and in the lowest member, the Elgin, cephalopods are a particularly conspicuous element. Fairly recently the cephalopods were monographed by Foerste, who dealt almost exclusively with their morphology. The general stratigraphy and paleontology of the formation have been discussed in detail by Ladd. We propose to deal primarily with the unusual local abundance of nautiloids where they form a coquina.

The best exposure of this cephalopod coquina is in a cut made in 1911 by the Chicago Great Western Railway Company about a quarter of a mile southwest of Graf, Dubuque County, Iowa. This cut now carries a gravel road as well as the railroad and it is therefore readily accessible. It is about 30 feet deep and 700 feet long, and the rocks exposed belong to the Elgin member of the Maquoketa formation—the underlying Galena limestone crops out in a stream bed a short distance to the northeast. Near the middle of the exposed section there are about 4½ feet of argillaceous limestone which consists largely of one species of cephalopod, *Dolorthoceras sociale* (Hall), in direct association with a few representatives of *Endoceras*, *Spyroceras*, and *Beloitoceras*, as well as rare small graptolites, bryozoans, brachiopods, gastropods, trilobites, etc. These nautiloid beds can be followed continuously for the entire length of the cut. Few, if any, cephalopods occur in the underlying or the overlying strata here. The matrix in which the specimens are imbedded is an argillaceous limestone with thin intercalated shale beds, and in weathered outcrops, at least, it is light brown in color. Ladd (1929, p. 343) stated that these "*Orthoceras* beds are also found [some two and a half miles northeast of Graf] in the northeast quarter of section 29, Center township, Dubuque county, six feet above a northwest flowing tributary of Little Maquoketa" River.

At the Graf locality the straight cephalopods occur in profusion. In an occasional talus block (e.g., pl. 40 fig. 1) they are more or less aligned with their long axes approximately parallel. However, for the most part, their orientation is heterogeneous and follows no pattern whatsoever (pl. 40 fig. 2). The great majority are more or less parallel to the bedding planes, but some are strongly inclined. In many cases individuals are telescoped (pl. 42, figs. 4–6) and it is not unusual to find as many as three (and in rare cases four) telescoped together (pl. 42, figs. 4, 6). The orientation of telescoped specimens is in some instances reversed (pl. 42, fig. 5).

In various parts of the geological column fossil cephalopods are not rare in which the filling of the living chamber contains other fossils, including smaller cephalopods. The same is true for the large siphuncles of Early Paleozoic forms; see, for example, *Endoceras duplicatum* Hall of the Trenton of New York. However, the Maquoketa specimens are unusual in that the telescoping extends far beyond the living chamber, fracturing the septa of the chambered portion of the conch, the phragmacone. As noted by Whitfield (1895, p. 71), this condition was probably facilitated by the

fact that in this species the siphuncle is small and the septa are thin and presumably therefore they were fragile (pl. 42, fig. 7). The walls of the conch were almost certainly relatively thick and strong so that they withstood the stress of the breaking of the septa and the siphuncle. Nevertheless, many telescoped individuals were later crushed. In some cases the crushing was so extreme that opposite walls of the conch are now in contact. Presumably the walls of these specimens were fractured and thereby weakened during accumulation, and then they were crushed as a result of compaction due to the weight of sediments that accumulated later. Shells that were filled with sediment were of course much less subject to crushing, and many individuals are essentially free from distortion.

We sectioned some of these specimens, and the one illustrated by figure 7 on plate 42 shows the internal features of the phragmacone particularly well. The septal necks are short and distinctly recurved. The connecting rings are subcylindrical but, nevertheless, the siphuncular segments are considerably expanded within the camerae. Most of the septa in the illustrated thin section are more or less destroyed as a result of recrystallization. In and adjacent to the former positions of these septa, there are traces of structures that might be regarded by some as indigenous partial cameral fillings. Also, in the siphuncle there are calcareous deposits. These are thickest in the adapical portion of each siphuncular segment, and their magnitude decreases adorally so that in the adoral three or four camerae of the figured section they are completely absent. The regularity and symmetry of these siphuncular deposits suggest to us that they are organic in origin and were formed during the life of the individual. The fact that they are progressively thicker in the adapical portion of the conch may indicate that they served as ballast, or may merely be a result of the fact that the adapical camerae were formed first and therefore deposits in them had a longer time during which to be secreted, or they may be a result of a combination of these circumstances.

After a general study of the Maquoketa formation and its fauna, Ladd (1929, p. 409) concluded that there "is considerable evidence which indicates that these early Maquoketa waters were exceedingly shallow. In this connection may be mentioned the jumbled *Orthoceras* beds of Graf in which shells of *Orthoceras* [*Dolorthoceras*] *sociale* are often telescoped, one into the other, the internal septa being broken. This suggests wave action as do also the fragmentary remains of trilobites and other forms." Our observations tend to confirm Ladd's conclusions, and the fact that all the specimens are not parallel to the bedding planes and that many of them are telescoped into one another through the septa indicates that the wave action was very strong. It should also be mentioned that the telescoping is not confined to the orthoceraconic forms, for in the representative of *Beloitoceras* illustrated by figures 1–4 on plate 41 there is a *Dolorthoceras sociale* which extends through the living chamber and into the phragmacone. This cyrtoceraconic form may also have had thin septa. However, our collections contain a few representatives of *Endoceras*, like that illustrated on plate 41, in which the septa were almost certainly thick, and their phragmacones contain *Dolorthoceras sociale* which transverse the septa—one is present in the adoral portion of the figured individual.

There is of course no parallel to this occurrence among modern forms, for all of the living tetrabranchiate cephalopods are coiled. These contemporary nautiloids live in moderately shallow waters about the coral reefs and islands of the South Pacific from the Philippines to the Fiji Islands. Their empty shells, however, drift widely and have been found on the shores of such

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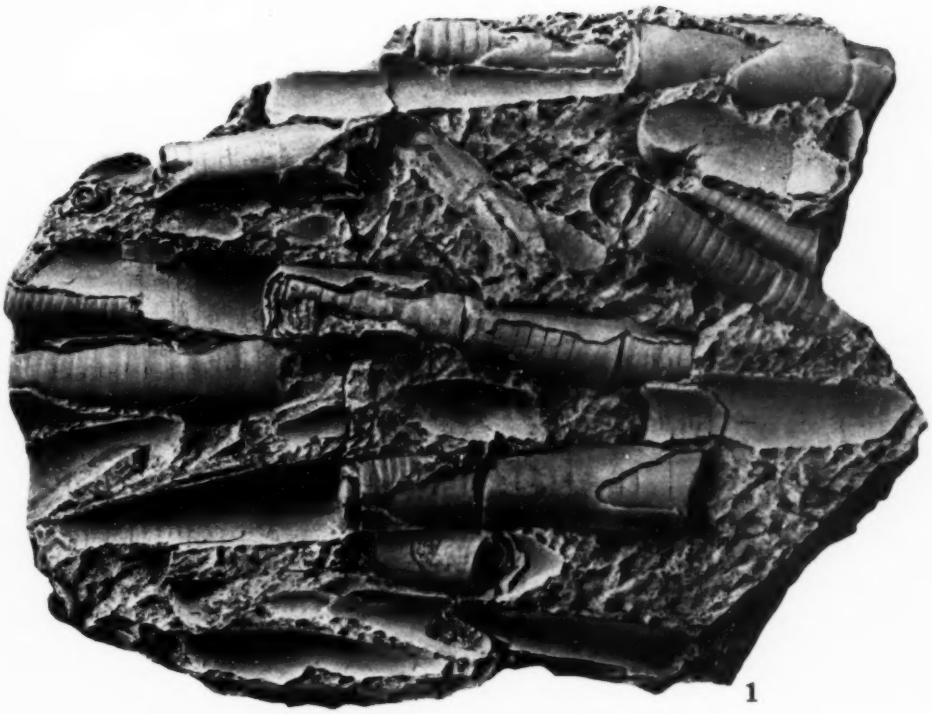
EXPLANATION OF PLATE 40

FIGS. *1, 2*—Two slabs of argillaceous limestone showing *Dolorthoceras sociale* (Hall) in almost parallel (fig. *1*) and random (fig. *2*) orientation, both from the Elgin member of the Maquoketa shale about ¼ mile southwest of Graf, Iowa, and both about ×⅔. (p. 199)



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Miller and Youngquist, Maquoketa Cephalopods

Miller and Youngquist, Maquoketa Cephalopods

remote localities as Japan, New South Wales, and Africa. Probably the shells of *Dolorthoceras sociale* were not so buoyant as those of modern nautilus because of their shape and because of the fillings within the siphuncle (and possibly also the camerae). Presumably, therefore, they came to rest at no great distance from the habitat of the animals which bore them. They were almost certainly concentrated by the joint action of local currents, eddies, and waves. Storm waves then are believed to have reworked the accumulation and to have accomplished most of the fracturing and telescoping of the shells. Such violent wave action would also destroy much if not all of the initial orientation which the shells may have had as a result of currents, and furthermore it would tend to obliterate the original bedding planes and to deposit the shells in a heterogeneous fashion.

Somewhat comparable occurrences of cephalopods are known at several other localities. For example, Clifton (1944, pp. 1018, 1031) has recorded the abundant accumulation of *Pseudorthoceras* in the Middle Permian Blaine and Dog Creek formations of north-central Texas. He stated that an "example of possible orientation by waves is suggested by phragmacones" of these nautiloids, for "in a thin carbonate stratum . . . it was estimated that 50 per cent or more of the nautiloid phragmacones in this stratum are now oriented northeast and southwest, with the adoral end of the phragmacones northeastward." At the same locality, that is, the falls on Salt Croton Creek, representatives of the ammonoid genus *Perrinites* are so abundant in certain beds that they form what is essentially a coquina. However, Clifton concluded, contrary to our view, "that waves or currents were little responsible for such concentrations" of nautiloids and ammonoids. Like Flower (1942, p. 38), we believe that "extensive" transportation of nautiloid shells is not applicable to any fauna rich in numbers of species and individuals.

Locally, other beds in the Permian of north-central Texas likewise tend toward being a coquina of mollusks, including many nautiloids, for example, the so-called "Lytle limestone" member of the Arroyo formation and beds near the base of the Lueders limestone. Mrs. A. H. Kemp of Seymour, Texas, loaned us a block of limestone from the latter beds in which orthoconic nautiloids are telescoped into one another. Also, Böse (1919, p. 114) has mentioned that in the Word formation of the Glass Mountains of west Texas, "*Agathiceras* occurs by the thousand in certain beds." Furthermore, the Mississippian Caney shale of Oklahoma and White Pine shale of Nevada contain limestone lenses that are composed largely of goniatites. Other examples could, of course, be cited from various parts of the geologic column in North America. Nielsen (1935, p. 20) in discussing the Permian at at Godthaab Gulf of eastern Greenland, mentioned that in "several places the whole surface of one of the two lower limestone bands can be seen to be covered with long, acute Tetracorals (?), all pointing in the same direction;" and according to Alfred G. Fischer (1947, pp. 6, 7) these supposed tetracorals are belemnoid rostra.

Our knowledge of European stratigraphy and paleontology is limited. Nevertheless, a few abundant accumulations of Paleozoic cephalopods there have come to our attention. For example, the members of The Permian Excursion of the Seventeenth International Geological Congress visited an outcrop of the lower Artinskian beds about 13 km. below Gubakha on the Kossva River of the west slope of the Middle Urals where there is exposed a dark gray limestone that is largely composed of ammonoids and nautiloids and a few other marine invertebrates.

EXPLANATION OF PLATE 41

FIGS. *1–4*—*Beloitoceras grafense* Miller and Youngquist, n. sp. Four views of the holotype, in which is imbedded a representative of *Dolorthoceras sociale* (Hall), from the Elgin member of the Maquoketa shale about ¼ mile southwest of Graf, Iowa, ×1. (p. 202)

5—*Endoceras* sp. A large, slightly crushed specimen, from the same zone and locality as the preceding, ×⅔. (p. 200)

The members of The Novaya Zemlya Excursion of the same Congress saw a comparable occurrence of ammonoids (and a few nautiloids) in the Carboniferous of the vicinity of Archangel Bay near the northern end of Berkh Island on the northwestern coast of the northern island of Novaya Zemlya. H. A. Lowenstam has called our attention to the fact that in 1927 Quenstedt discussed other occurrences, and he (1927, p. 412) mentioned the association of abundant orthoconic nautiloids and graptolites, which is reminiscent of the Graf fauna.

ADDENDUM

Since the publication of Foerste's study of the nautiloid cephalopods of the Maquoketa shale of Iowa, two exceptional specimens have become available. Both of these represent new species, though Foerste described and illustrated a fragmentary representative of one of them.

BELOITOCERAS GRAFENSE Miller and Youngquist, n. sp.
Plate 41, figures 1–4

Beloitoceras cf. *B. whitneyi* FOERSTE, 1936 [1935], Denison Univ. Bull., Jour. Sci. Labs., vol. 30, pp. 252–253, pl. 37, fig. 3.

Recent collecting in the lower Maquoketa shale near Graf, Iowa, has yielded a specimen that is similar to but more nearly complete than the one from the same locality that Foerste illustrated and described as *Beloitoceras* cf. *B. whitneyi* (Hall). The additional specimen indicates that, as Foerste suspected, this form is specifically distinct from typical *B. whitneyi*. Accordingly we are proposing a name for it and are designating as the holotype the more nearly complete specimen (which, however, is very slightly crushed).

The conch is cyrtoceraconic and is intermediate between a typical longicone and a typical brevicone. The adapical part of the holotype is more strongly curved than the adoral, which has an almost straight dorsum. This specimen appears to be essentially complete adorally but not adapically. The preserved part of it attains a maximum overall length of about 76½ mm. The cross section is essentially elliptical as the conch is compressed laterally—however, it is very slightly more narrowly rounded ventrally than dorsally. At the junction of the phragmacone and the living chamber the height of the conch of the holotype measures about 37 mm. and the corresponding width about 28 mm.

The living chamber, which in the holotype is about 22 mm. long, is slightly but distinctly contracted adorally. The aperturral margins are nearly straight, but there appear to be slight lateral and ventral sinuses.

Both of the specimens are internal molds, which retain traces of the test. The surfaces of the molds are marked by longitudinal lirae which are low, broad, flat and separated by relatively wide interspaces. Also there are transverse band-like markings which are parallel to the sutures. Both the transverse and longitudinal markings are largely if not entirely, confined to the phragmacone, and they seem to end rather abruptly immediately orad of it, where the transverse ornamentation is particularly prominent. It seems probable that the longitudinal and much of the transverse ornamentation on the internal mold is merely an impression of that of the outer surface of the test, but that the relatively prominent transverse band at the adapical end of the living chamber is primarily a feature of the internal mold.

As shown by the accompanying illustrations, the camerae are rather short. The sutures are essentially straight and directly transverse. However, due to the lateral

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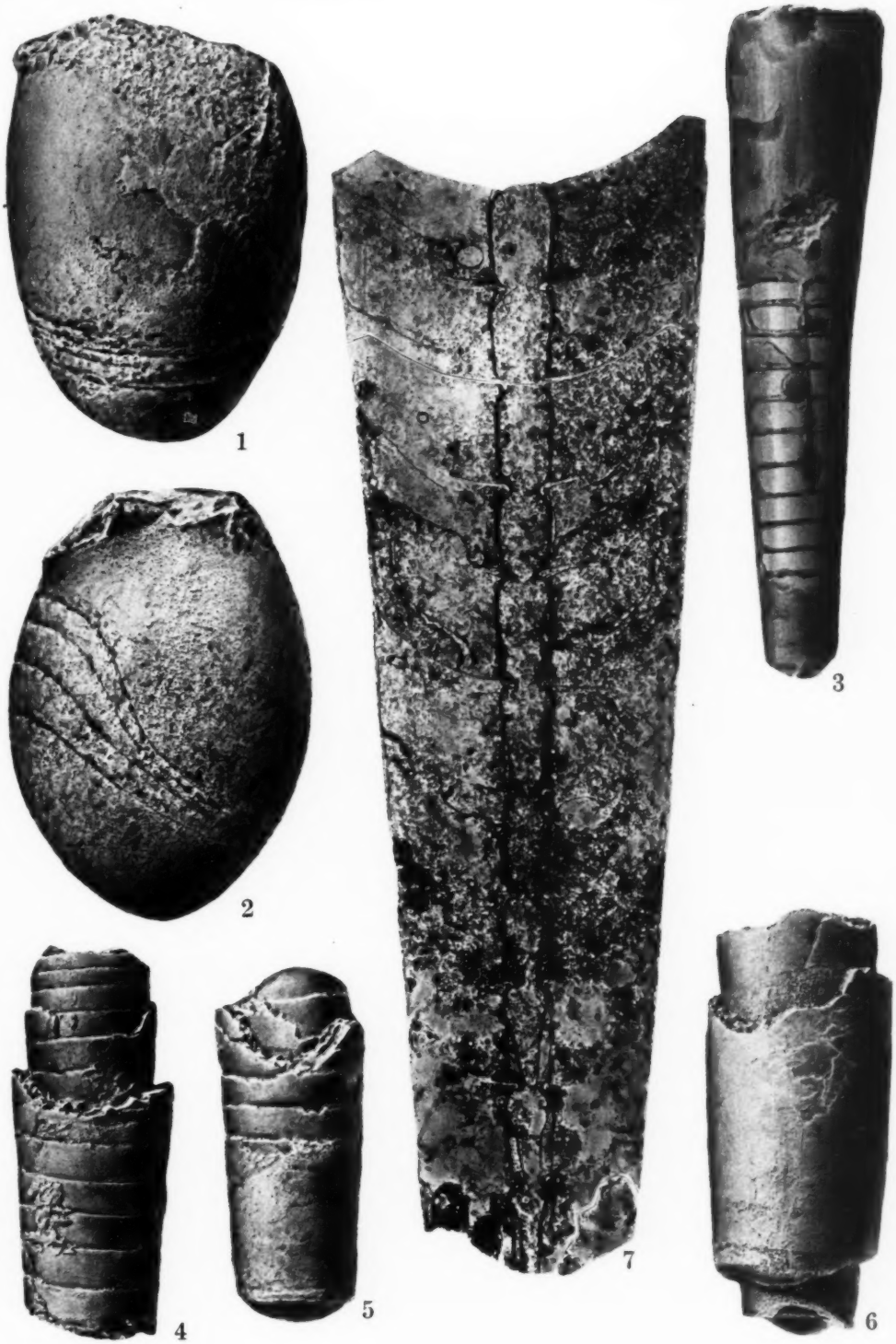
EXPLANATION OF PLATE 42

FIGS. *1, 2*—*Probillingsites pronis* Miller and Youngquist, n. sp. Ventral and lateral views of the holotype, from the Elgin? member of the Maquoketa shale of Fayette County, Iowa, ×1½. (p. 203)

3–7—*Dolorthoceras sociale* (Hall). A large fairly complete specimen, ×1 (fig. *3*); telescoped specimens, ×1½ (figs. *4–6*); and a median longitudinal thin section through the siphuncle, ×7½ (fig. *7*); all from the Elgin member of the Maquoketa shale about ¼ mile southwest of Graf, Iowa. (p. 199)



Miller and Youngquist, Maquoketa Cephalopods

compression of the conch, they form very slight lateral lobes and corresponding dorsal and ventral saddles.

The siphuncle is exposed at the adapical end of the holotype, where it is about 4 mm. in diameter and it is located about 2 mm. from the venter. Its structure was not determined.

Remarks.—The holotype of this species is slightly smaller than Foerste's specimen (which is available to us for direct comparisons), but otherwise the two do not differ materially. Each of the specimens contains a representative of *Dolorthoceras sociale* (Hall).

As noted by Foerste, compared to typical *B. whitneyi*, this species "is larger, is straighter dorsally, and contracts distinctly dorsoventrally along the living chamber." Furthermore, in general physiognomy, the two are not very closely similar, and *B. grafense* resembles *B. cumminsi* Flower of the Whitewater member of the Richmond of Ohio in this respect.

Occurrence.—The holotype (and presumably also the paratype) came from near the top of the so-called "Orthoceras beds" of the Elgin member of the Maquoketa formation about ¼ mile southwest of Graf, Dubuque County, Iowa.

Types.—State University of Iowa, 4936 (holotype) and 8205 (paratype).

PROBILLINGSITES PRONIS Miller and Youngquist, n. sp.
Plate 42, figures 1, 2

The single specimen on which this species is being based is a rather well preserved internal mold, which, however, is somewhat distorted. Its overall length measures about 45 mm., and the maximum height and width of its conch are both approximately 32 mm. The conch is globular, and its general shape is shown by the accompanying illustrations. The adoral portion is considerably contracted, but the apertural margins are not preserved. No trace of the surface ornamentation is discernible on the only known representative of the species.

The camerae, of which there are four in the holotype, are very short in the ventral half of the specimen but they are considerably longer in the dorsal half. The sutures are strongly oblique to the long axis of the conch, sloping orad from the venter, and they are sinuous. Furthermore, their sinuosity increases progressively orad. Each forms a broad rounded ventral lobe and a corresponding dorsal saddle. Their course across the lateral zones of the conch is sigmoidal (pl. 42, fig. 2). Near the adapical end there is a small round structure that may represent the siphuncle.

Remarks.—This species is more advanced than the genotype of *Probillingsites*, *P. welleri* Foerste, probably from the Galena dolomite of Illinois or Wisconsin; and it is less advanced than typical *Billingsites* and *Schuchertoceras*. Of all the species with which we are familiar, it seems to be closest to *P. manitoulinensis* (Foerste) of the Meaford member of the Richmond of Manitoulin Island, a somewhat smaller and less globular form.

Occurrence.—The holotype, which is preserved in light buff finely crystalline even-textured limestone, was found by A. O. Thomas in the Maquoketa shale of Fayette County, Iowa. Most probably it came from the Elgin member of that formation.

Holotype.—State University of Iowa, 4937.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 205–209, PL. 43, 3 TEXT FIGS., MARCH 1949

A NEW TYPE OF THE FUSULINID FORAMINIFERA FROM CENTRAL JAPAN

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ABSTRACT—*Acervoschwagerina endoi*, a new subgenus and a new species of the fusulinid genus *Paraschwagerina* is described. It closely resembles *Paraschwagerina* in which the septa are intensely and regularly fluted, but is distinguished by having septa fluted in an irregular and complex manner. This new type of Foraminifera was found in limestone from Gombo, Nyukawa-mura, Ōno-gun, Gifu Prefecture, Japan, and is referred to the Lower Permian.

INTRODUCTION

IN 1934, Professor Seido Endo collected samples of Paleozoic limestone from a quarry at Gombo, Nyukawa-mura, Ōno-gun, Gifu Prefecture, Central Japan (Lat. 36°10′N, long. 137°22′E) and kindly submitted them to me for study. I had previously noticed several fragments of a peculiar type of fusulinid in some thin sections of this limestone. These Foraminifera, however, occur scattered sporadically in random directions in the gray, compact, indurated rock and are inseparable from the matrix and I had failed to obtain well oriented sections. Thus, the generic and specific characters of these fusulinids remained unknown. Recently, however, I made several new thin sections of the limestone and was fortunate in obtaining centered axial and sagittal sections, in addition to several tangential and slightly excentric sections and was thus able to determine the external as well as the internal structures of the Foraminifera. As described below, this fusulinid bears a close resemblance to the genus *Paraschwagerina*, but the irregularly and complexly fluted septa distinguish it from that genus. Therefore, I propose for this new type of Foraminifera, a new subgeneric and a new specific name, *Acervoschwagerina endoi* of the genus *Paraschwagerina*.

In the summer of 1943, I visited this fossil locality with Mr. Hisashi Nishino to study the geology and the occurrence of the limestone. I was successful in collecting additional specimens and Mr. Nishino has intermittently carried on further areal geologic mapping.

In addition to the limestone, the Paleozoic formations of the district include thin-bedded chert, schalstein, graywacke, and phyllitic slate. These rocks crop out along the Shohachiga River, parallel with the highway from Takayama City to Hirayu Hot Spring. The regional strike is from east to west with southward and northward dips at angles of 70°–90°.

In his recent field work, Nishino discovered an exposure of *Fusulinella* limestone, 20 meters thick and 500 meters long at Nakabata, one kilometer north of Gombo, the type locality of the present new form. The *Fusulinella* limestone is embedded in a chert which is succeeded southward by graywackes and phyllitic slates. The *Acervoschwagerina* limestone is exposed along the highway above mentioned from Kono to Ashiya by way of Gombo, Kasane, and Shirai. The thickness is 200 meters and the outcrops extend for a distance of four kilometers. The limestone is succeeded to the north by a chert and graywacke complex, and to the south by schalstein, thin-bedded cherts, and graywackes. Another complex of chert, schalstein, and graywacke with *Parafusulina* and *Neoschwagerina* limestones lies to the south in the southern portion of Nyukawamura and the northern portion of Daihachiga-mura of Ōno-gun. Nishino very recently discovered a conglomerate with round pebbles of chert and graywacke in the Paleozoic at Nakabata midway between the outcrop of the *Fusulinella*-limestone and that of the *Acervoschwagerina*-limestone at Gombo. He interpreted this conglomerate as marking a physical break between the Moscovian, represented by the *Fusulinella*-limestone, and the Sakmarian, represented

by the *Acervoschwagerina*-limestone, although he could not, from the poor exposures, determine the stratigraphic relation between the conglomerate and other sedimentary rocks. Although the cherts and phyllites show complicated contortions as well as minor folding and numerous thrust faults, the over-all structure of the Paleozoic

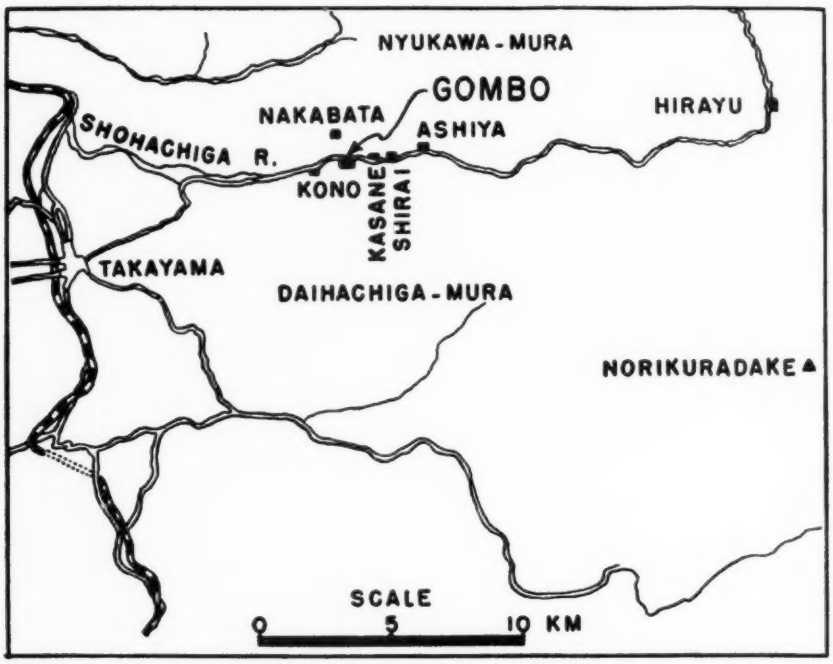


FIG. 1—Locality Map of *Paraschwagerina* (*Acervoschwagerina*) *endoi* Hanzawa, n. subgen. and n. sp.

formations is homoclinal and the formations to the north are older than those to the south of the fossil locality. The *Fusulinella*-limestone at Nakabata is safely referred to the Moscovian and the *Parafusulina*- and *Neoschwagerina*-limestones in Daihachigamura, to the Artinskian. I identified *Schwagerina* sp. and *Parafusulina* sp. in limestone samples collected by Nishino from Shirai, which occurs at the same stratigraphic position as *Acervoschwagerina endoi*. Thus, I assign the *Acervoschwagerina* zone to the Sakmarian, since it lies stratigraphically above the *Fusulinella*-horizon of the Moscovian and below the *Neoschwagerina*-horizon of the Artinskian. In the area under discussion, the Artinskian rocks conformably overlie the Sakmarian which in turn probably disconformably rest upon the Moscovian. Between the *Fusulinella*-limestone and the *Acervoschwagerina*-limestone, there is no formation carrying a *Triticites*-fauna and representing the Uralian in a narrow sense. A chert and schalstein complex is exposed in a fairly wide area north of the *Fusulinella*-limestone. The last mentioned complex, with a conglomerate at the base, is unconformably underlain by another thick formation of phyllite and graywacke. Nishino established the order of succession of the Paleozoic formations in this district as follows in ascending order.

(1) The Moribe formation, the lowest unit of the Paleozoic in this area, is present only to the north and is an alternation of graywacke and phyllitic slate. As the base of this formation is not exposed here, its thickness is unknown. However, the formation is more than 500 meters thick.

(2) The Ōnuma formation is exposed in a narrow area to the south of the preceding formation, and overlies disconformably the

last mentioned formation, with a basal conglomerate 100 meters in thickness. This formation is about 600 meters thick, and consists largely of schalstein with occasional intercalated thin-bedded cherts and grades upwards into the next formation.

(3) The Nakabata formation is present in an area extending east and west between the Ōnuma and Gombo formations and consists of thin-bedded chert with a lenticular limestone of 200 meters maximum thickness in portion of the area. It consists of chert and graywacke with a limestone, 200 meters thick in the lower part and schalstein, thin-bedded chert, and graywacke in the upper part. This formation totals 600 meters in thickness. The limestone contains the new type of fusulinid, here described, besides *Parafusulina* sp. and *Schwagerina* sp., and is assigned to the Sakmarian. This formation grades upwards into the next succeeding formation.

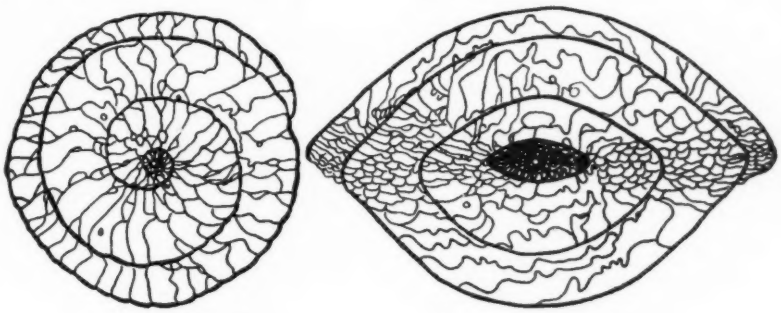


FIG. 3 FIG. 2

FIGS. *2, 3*—Axial and sagittal sections of *Paraschwagerina* (*Acervoschwagerina*) *endoi* Hanzawa, n. subgen. and n. sp., restored from several random sections, about ×4.5.

the lower part and alternations of graywacke and phyllitic slate in the upper part. The limestone, which contains numerous *Fusulinella*, is assigned to the Moscovian or may be correlated with the Lower Desmoinesian and the Upper Derryan stages.

In Japan, no fusulinids assignable to the genus *Fusulina* have ever been found and the *Fusulinella*-bearing rocks are directly succeeded by younger fusulinid-bearing rocks with *Pseudoschwagerina*. Not only the *Triticites* zone of the Missourian and the Virgillian of America, but also the *Fusulina* zone of the upper and middle Desmoinesian of America are missing in Japan. I surmise that Japan was emergent from middle Desmoinesian to Virgillian time or the sedimentary rocks of those ages if deposited have been subsequently removed by subaerial denudation. A stratigraphic hiatus between the *Fusulinella*-bearing rocks and the *Pseudoschwagerina-Quasifusulina* rocks occurs in the Kitakami massif of northeastern Honshu.

(4) The Gombo formation is exposed along the Shohachiga River in the middle

(5) The Daihachiga formation is present in a wide area to the south of the Gombo formation and is a thick complex of schalstein, chert, and graywacke with several intercalated limestones, tens of meters thick. This formation is estimated to be 800 meters in thickness. Some intercalated limestone lenses in this formation contain *Neoschwagerina*, *Parafusulina*, and other smaller fusulinids. Therefore it is referred to Artinskian.

SYSTEMATIC DESCRIPTION

FUSULINIDAE von Möller, 1878

SCHWAGERININAE Dunbar and Henbest, 1930

Genus PARASCHWAGERINA Dunbar and Skinner, 1936

Subgenus ACERVOSCHWAGERINA Hanzawa, n. subgen.

Subgenotype: ACERVOSCHWAGERINA ENDOI Hanzawa, n. sp.

Test large, robustly fusiform; juvenarium fusiform, closely coiled as in *Schwagerina*, followed by the rapidly inflated volutions of

the adult test; inflation of the final whorl relatively less; spirotheca consists of tectum and keriotheca; septa relatively thick and regularly folded in juvenarium as in *Schwagerina;* in later stages of growth, thin, irregularly fluted, forming disorderly assemblage of vesicular or tubular chamberlets; chomata virtually absent. Sakmarian of Japan.

Remarks.—This new subgenus may have been derived directly from *Schwagerina* or from *Paraschwagerina.* The present form stands close to *Paraschwagerina* in external features and in the mode of growth of the test. Although the septa of *Paraschwagerina* are intensely fluted, the fluting is regular so that in tangential section, the opposed folds of the adjacent septa meet near the base, subdividing the meridional chambers into cell-like chamberlets of rhombic form. The septa of *Acervoschwagerina* on the other hand are very irregularly and intensely fluted. Instead of making a regular rhombic mesh-work in tangential section, the folds of the septa produce a confused aggregate of arcuate chamberlets.

ACERVOSCHWAGERINA ENDOI Hanzawa, n. sp.

Plates 43, figures A–D, text figures 2 and 3.

Test large, broadly fusiform; attaining 18.6 mm. in length and 8.2 mm. in width; a spherical or somewhat deformed proloculus and five or a little more whorls included; juvenarium schwagerine and comprising two or three tightly coiled whorls which are followed by two or three rapidly inflated adult volutions and a relatively lower final whorl; proloculus 147 to 162 μ by 230 μ, its compact wall 30 μ thick; spirotheca thin, 20 μ thick in first and second whorls, 34 μ in forth and fifth, and 88 to 98 μ in last whorl; delicately alveolar in structure; lamellae of keriotheca 5 to 10 μ thick; interval between adjacent lamellae, 24 μ in last whorl; septa comparatively thick, 34 μ in thickness, regularly folded in juvenarium; very complexly fluted in later growth stages forming vesicular chamberlets only 10 to 20 μ in width; septal count considerable but indeterminable.

Dimensions of three specimens are shown in the following table:

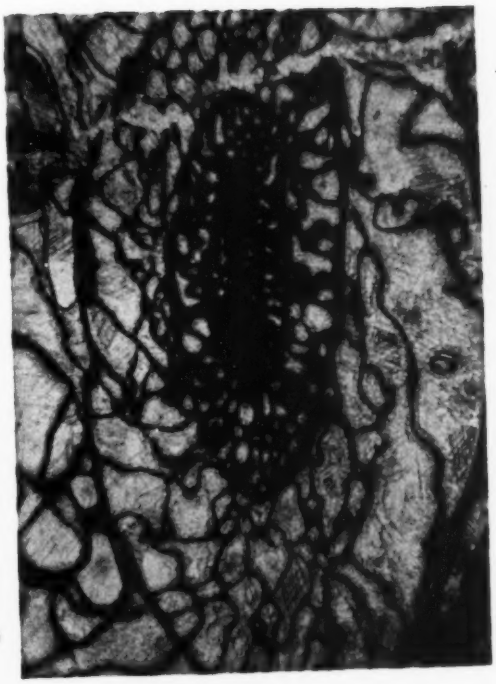
Specimens / Whorl	Width in mm			Length in mm			Ratio of width to length		
	A	B	C	A	B	C	A	B	C
Proloc.	0.16	0.14		0.16	0.23				
1st	0.52	0.33	0.28	1.50	0.59	0.56	1:2.2	1:1.7	1:1.6
2nd	1.04	0.46	0.48	2.30	9.86	1.11	1:2.2	1:1.8	1:2.2
3rd	2.04	0.78	9.58	7.80	1.29	2.60	1:3.7	1:1.6	1:4.5
4th	4.75	1.11	2.60	14.50	2.80	5.20	1:3.1	1:2.5	1:2.0
5th	7.50	5.20	7.30	17.20	7.40	9.40	1:2.5	1:1.5	1:1.3
6th		7.80	8.20		15.80			1:1.6	

EXPLANATION OF PLATE 43

FIGS. *A–D—Paraschwagerina* (*Acervoschwagerina*) *endoi* Hanzawa, n. subgen. and n. sp. Cotypes, Gombo, Nyukawamura, Ono-gun, Gifu Prefecture, Japan. (I.G.P.S. Coll. Cat. no. 21962). Figure *A*, central, part of sagittal section, ×16.5, showing closely coiled juvenarium, rapidly inflated later whorls, and septal fluting; figure *B*, central part of axial section, ×16.5 showing *Schwagerina*-like juvenarium, rapidly inflated later whorls, and septal fluting; figure *C*, central part of tangential section cut near surface of test, ×16.5, showing the vesicular structure of the chamberlets; figure *D*, showing *Schwagerina*-like juvenarium and irregularly fluted septa.

(p. 208)

2



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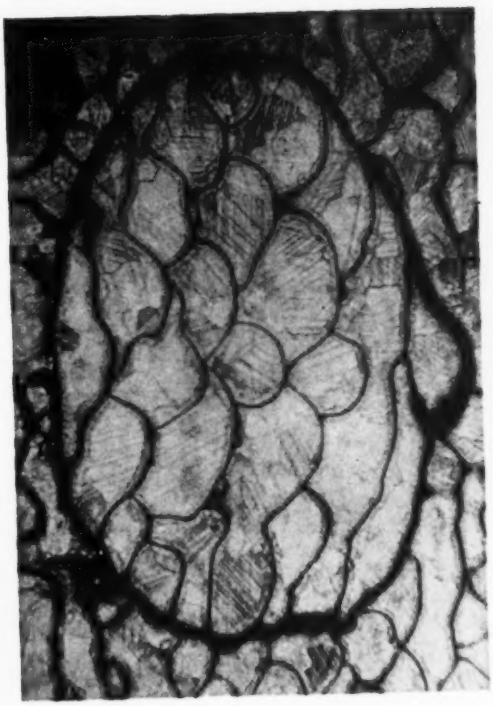

3

Hanzawa, *Acervoschwagerina* endoi

These dimensions show that the growth rate is irregular, especially in the juvenarium. Full length is attained in five or five and a half whorls.

Geological Horizon and Locality.—Gombo formation, Sakmarian, Lowest Permian. Gombo, Nyukawa-mura, Ōno-gun, Gifu Prefecture, Japan. S. Endo, coll. Institute of Geology and Paleontology, Sendai Coll. Cat. no. 21962. The present form is associated with *Schwagerina* sp. and *Parafusulina* sp.

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 210–213, PLS. 44–45, MARCH 1949

A NEW MIOCENE *LEPIDOCYCLINA* FROM SHIZUOKA PREFECTURE, JAPAN[1]

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ABSTRACT—*Lepidocyclina* (*Nephrolepidina*) *makiyamai*, n. sp., is described from the Saigo formation in Shizuoka prefecture, Japan. This species is related to *L.* (*N.*) *rutteni* (VAN DER VLERK) which is characteristic of the f3 stage (Vindobonian) of the East Indies Tertiary sequence. Because of this relation, and from stratigraphic considerations, the *Lepidocyclina-Miogypsina* assemblage of the Saigo formation is correlated with that of f3 stage (Vindobonian) of the East Indies sequence.

STRATIGRAPHIC NOTES

ASSEMBLAGES of *Lepidocyclina* and *Miogypsina* formerly recorded from Japan bear close relations to the *Lepidocyclina-Miogypsina* assemblages of the f1–2 stage of the East Indies stratigraphic sequence, which is correlated with the Burdigalian stage (middle Miocene) of the European sequence. *Lepidocyclina* (*Nephrolepidina*) *japonica* (Yabe, 1906) and *Lepidocyclina* (*Nephrolepidina*) *nipponica* (Hanzawa, 1931), which may be synonymous, are closely related to *L.* (*N.*) *angulosa* Provale according to Hanzawa (1947); the association of typical nephrolepidine *Lepidocyclina* with *Miogypsina* in the absence of *Spiroclypeus* strongly suggests the correlation of such assemblages with those of the f1–2 stage of the East Indies sequence.

Lepidocyclina (*Nephrolepidina*) *makiyamai*, n. sp. described herein, is closely related to the so-called trybliolepidine form *Lepidocyclina* (*Nephrolepidina*) *rutteni* (van der Vlerk), found with *Miogypsina* in the f3 stage of the East Indies, which is equivalent to the Vindobonian stage of the European sequence. *L.* (*N.*) *makiyamai*, n. sp., was found in the basal Tozawa bed of the Saigo mudstone formation at two localities.

J. Makiyama, who has studied the stratigraphy of the Kakegawa district in detail (1931, 1941, 1943, 1947) states that the Saigo formation lies unconformably on the middle Miocene Kurami group.

The Kurami group consists in ascending order, of the Amenomiya formation, the Matsuba formation and the Masago formation (figure 1). The Matsuba formation contains a large proportion of pyroclastic material whereas the lower and upper formations consist entirely of terrigenous sediments. The Kurami group contains fossils of Togarian (middle Miocene) age and, in the Futamata district, unconformably overlies rocks of the Ooigawan stage (lower Miocene) which is characterized by nephrolepidine types of *Lepidocyclina;* these larger foraminifers, which include *Lepidocyclina* (*Nephrolepidina*) *nipponica*, *L.* (*N.*) *angulosa* and *L.* (*N.*) *perornata*, are found in lentils of algal reef limestone in the Megami formation of the Ooigawa group. The *Lepidocyclina-Miogypsina* assemblage of the Saigo formation is, therefore, clearly in a considerably higher stratigraphic position than the *Lepidocyclina-Miogypsina* assemblage of the Megami formation, which can be correlated with f1–2 stage of the East Indies.

Although the larger Foraminifera from the Saigo formation are found in a pebbly sand just above the unconformity with the Kurami group, it is clear that they are not derived from older rocks because of the excellent preservation even of their detailed structure; also the unconformity does not represent a large hiatus and it is extremely unlikely that the lower part of the Ooigawa

[1] This paper forms part of a project initiated by Natural Resources Section, GHQ, SCAP, for the purpose of assembling paleontologic data applicable to petroleum exploration in Japan. This paper was edited by L. W. Stach, Head, Petroleum Branch, Natural Resources Section, who also contributed to the section on stratigraphic notes.

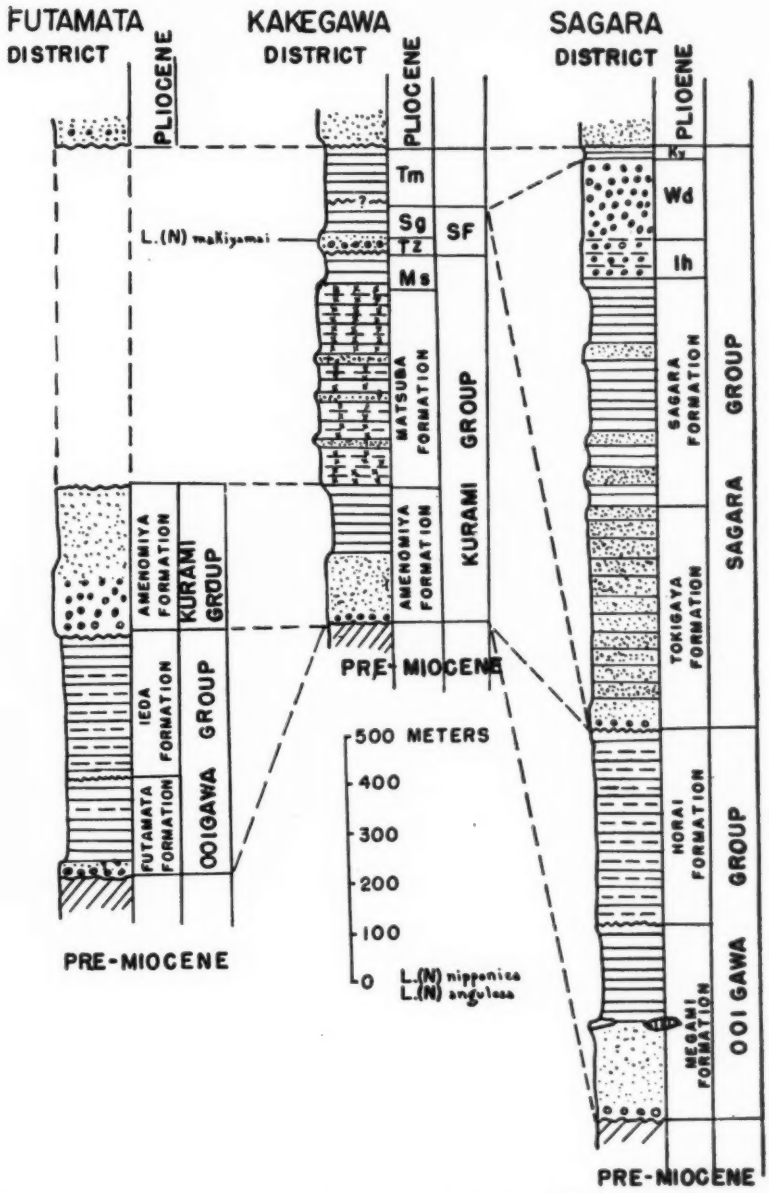


FIG. 1—Columnar sections illustrating Miocene stratigraphy in the Futamata, Kakegawa and Sagara areas, Shizuoka prefecture. Ih, Ishiharada bed; Ky, Kiriyama formation; Ms, Masago formation; SF, Saigo formation; Sg, Saigo mudstone; Tm, Tamari formation; Tz, Tozawa bed; Wd, Wada conglomerate.

group, which alone is known to contain larger Foraminifera, was exposed at the time of the hiatus.

It is therefore concluded that the new assemblage of larger Foraminifera from the Saigo formation can be correlated with f3 stage (Vindobonian) assemblages of the East Indies Teritary sequence.

DESCRIPTION OF SPECIES

Family ORBITOIDIDAE Schubert, 1920
Subfamily LEPIDOCYCLININAE Tan, 1936
Genus LEPIDOCYCLINA Gümbel, 1870
Subgenus NEPHROLEPIDINA Douvillé
LEPIDOCYCLINA (NEPHROLEPIDINA) MAKIYAMAI Morishima, n. sp.
Plates 44, 45

Description.—Test small, 3.5 to 4.3 mm. in diameter and 1.0 to 1.6 mm. in thickness, lens-shaped in cross section with dome-shaped central boss which is 1.5 to 2.4 mm. in diameter. In general, the peripheral outline is irregularly hexagonal or heptagonal and a series of elevated zones radiate from the center of the test to each angle of the periphery. Equatorial chambers of these elevated zones are ogival in horizontal section and the breadth of the elevated zones is about 0.35 mm. The relatively broad peripheral flange, which is usually partially destroyed, is about 1 mm. broad at its greatest width, 0.22 to 0.28 mm. thick at each angle and 0.12 to 0.23 mm. thick at the middle of each side. The heads of the pillars appear as 20 to 30 rather indistinct pustules on the surface of the central boss.

The form of nucleoconch is usually nephrolepidine, but in some specimens it approaches the trybliolepidine form in equatorial section. (plate 45, fig. 2)

The polygonally arranged equatorial chambers are arcuate near the nucleoconch and their radial length is nearly equal to the tangential length which increases towards the center of the test. In the third to fifth whorls adjacent to the auxiliary chambers, the tangential length is greater than the radial length. The equatorial chambers of the elevated radiating zones are ogival in form beginning from the fifth, sixth or seventh whorl from the auxiliary chambers and ending at the peripheral margin; each elevated zone is five to seven chambers wide in horizontal section. The chamber walls are composed of three layers; the outer and inner layers are optically similar and about 3μ thick; the middle layer appears darker in section and is 1.5μ in thickness. Communication pores on upper and lower walls of the equatorial chambers number 25 to 28 on each side. In vertical section, the lateral chambers are usually high in relation to their width, and each tier is composed of eight or nine lateral chambers. The pillars do not exceed 80μ in diameter, and their diameter remains almost constant from top to base.

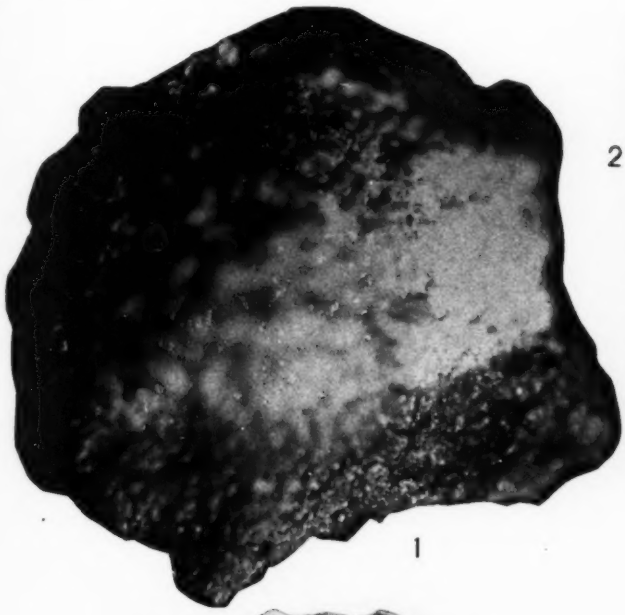
Dimensions.—

Diameter	3.5 to 4.3 mm.
Thickness	1.0 to 1.6 mm.
Central boss (diameter)	1.5 to 2.4 mm.
Nucleoconch	
First chamber	
diameter	104 to 178 microns
height (maximum)	78 microns
Second chamber	
diameter	118 to 252 microns
height (maximum)	117 microns
Partition between first and second chambers	
thickness	7 to 17 microns
wall (thickness)	22 to 39 microns
Auxiliary chambers	
diameter (maximum)	113 by 69 microns
Equatorial chambers	
Tangential length	40 to 55 microns
Radial length	34 to 56 microns
Height	24 to 61 microns
Roofs and floors	
thickness	13 to 34 microns
Vertical walls	
thickness	6 to 14 microns
Lateral chambers	
Width	112 to 162 microns
Height	34 to 54 microns
Roofs and floors	
thickness	10 to 18 microns
Number in a tier	8 to 9
Pillars	
Diameter	60 to 80 microns

Comparison.—This species is closely related to *Lepidocyclina* (*Nephrolepidina*) *rutteni* (van der Vlerk) and *L.* (*N.*) *nipponica* Hanzawa. The pustules of *L.* (*N.*) *makiyamai* are fewer than in *L.* (*N.*) *nipponica*, the equatorial chambers adjacent to the auxiliary chambers have no lateral walls,

EXPLANATION OF PLATE 44

FIGS. *1–4*—*Lepidocyclina* (*Nephrolepidina*) *makiyamai* Morishima, n. sp. *1*, exterior ×30, paratype L-1; *2*, equatorial section, ×30, paratype L-5; *3*, equatorial section, ×40, holotype L-7; *4*, section through the lateral chambers near base of mamelon, ×30, paratype L-12. Micropaleontological Collection, Kyoto Imp. Univ. (p. 212)



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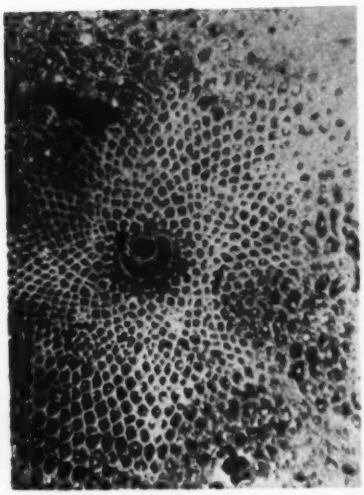

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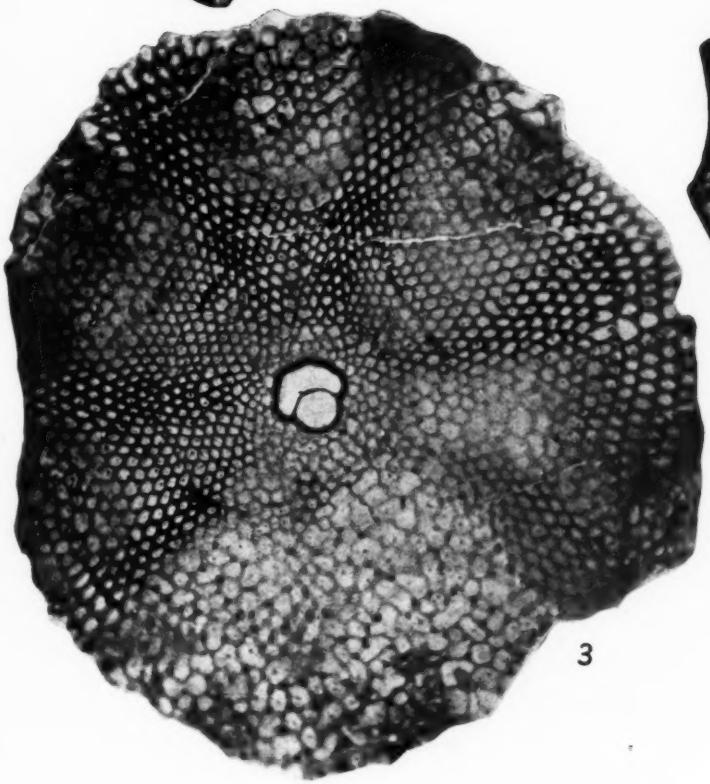

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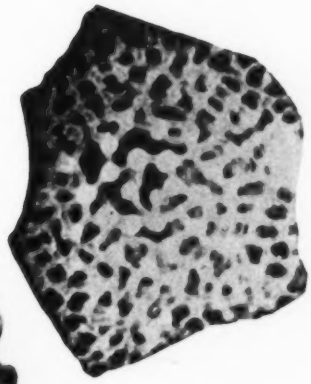

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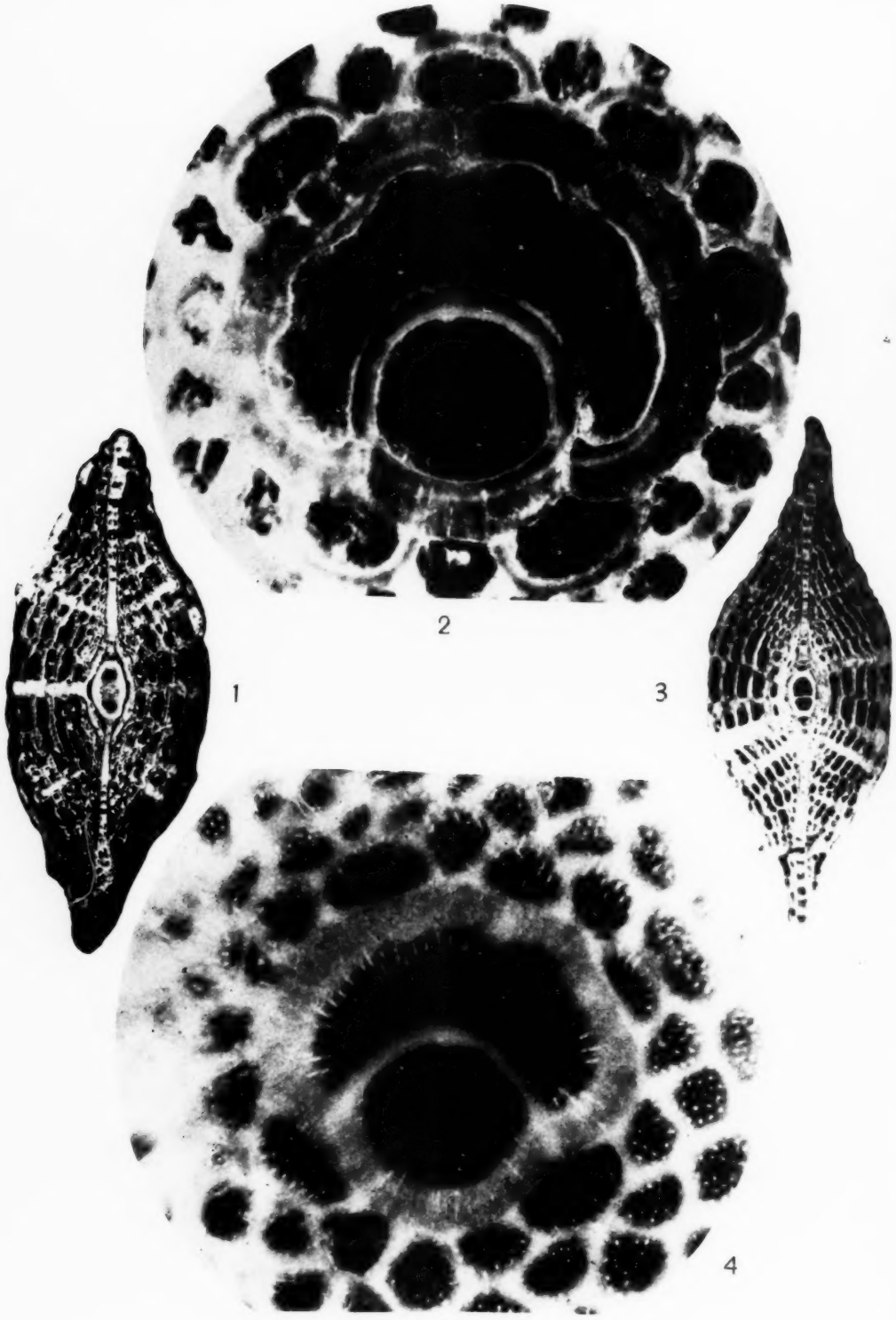
Morishima, Miocene *Lepidocyclina*



Morishima, Miocene *Lepidocyclina*

the elevated zones are more conspicuous, and the lateral chambers are higher and less numerous in a tier. *L.* (*N.*) *nipponica* var. *izuensis* Hanzawa has thicker pillars than *L.* (*N.*) *makiyamai*.

L. (*N.*) *makiyamai* agrees closely with *L.* (*N.*) *rutteni* (van der Vlerk) except for the nucleoconch. In the latter form the second chamber embraces about three-quarters of the circumference of the first chamber and the diameter of the nucleoconch is less than in *L.* (*N.*). *makiyamai*. Also the diameter of the pillars is smaller than in *L.* (*N.*) *rutteni* and the character of the elevated zones is somewhat different.

Type specimens.—Holotype No. L7, paratypes Nos. L1–6 and L8–16 inclusive, Kyoto Imperial University Micropaleontological Type Collection. Paratypes in the following institutions: Paleontological Collection, Stanford University, California; Paleontological Laboratory, Teikoku Oil Company, Tokyo; Geological Survey of Japan, Tokyo.

Type locality.—Locality No. M-1, small outcrop on the left bank of Kurami River, Shinzaike, Kurami-mura, Ogasa-gun, Shizuoka prefecture; Saigo formation, Miocene.

Distribution.—In addition to the type locality, *L.* (*N.*) *makiyamai* was also found at locality 9269, an outcrop of the Saigo formation along the pass a little south of the divide between Saigomura and Amazakura-mura to the north of Gomei, Saigomura, Ogasa-gun, Shizuoka prefecture.

Associated Fauna.—At the type locality, *L.* (*N.*) *makiyamai* is associated with *Miogypsina kotoi* Hanzawa and *Robulus* sp. At locality 9269, *Miogypsina kotoi* alone is found with *L.* (*N.*) *makiyamai*.

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EXPLANATION OF PLATE 45

FIGS. *1–4*—*Lepidocyclina* (*Nephrolepidina*) *makiyamai* Morishima, n. sp. *1*, vertical section, ×30, paratype L-11; *2*, *4*, enlarged equatorial sections of paratypes L-5 and L-7 respectively, ×220, showing shape of nucleoconch; *3*, vertical section, ×30, paratype L-6. Micropaleontological Collection, Kyoto Imp. Univ. (p. 212)

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 214–217, 1 TEXT FIG., MARCH 1949

FIVE NEW VARIETIES OF GRAPTOLITES FROM TENNESSEE AND VIRGINIA

CHARLES E. DECKER
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ABSTRACT—The following five new varieties of graptolites from the Athens shale are described and illustrated: *Diplograptus (Glyptograptus) euglyphus elongatus, D. (Amplexograptus) maxwelli rarithecatus, D. (Orthograptus) truncatus longithecatus, Glossograptus ciliatus robustus, G. ciliatus sparsithecatus.*

The Athens shale, an Ordovician formation, extends from north-central Alabama northeastward across eastern Tennessee to northern Virginia. It may be seen in scores of outcrops in this area of intense folding and faulting. It varies in thickness from a few feet to several hundred feet. Butts (1940, p. 165) has indicated a range in thickness in Virginia of from 200 feet or less to about 4,000 feet, but has estimated that locally the thickness may reach 5,000 to 10,000 feet. The fauna consists chiefly of graptolites and a few brachiopods and trilobites. In the study of many hundreds of specimens of graptolites, five have been found which have characteristics differing from those of other described forms by an amount which entitles them to be recognized as distinct varieties.

DIPLOGRAPTUS (GLYPTOGRAPTUS) EUGLYPHUS var. ELONGATUS

Decker n. var.
Figures 1, 1a, 1b

THIS variety is characterized by its extreme length of 130 mm. This is more than three times the normal length of the species and more than twice the greatest length assigned to the species. Also the thecae are much longer than those of the species, occurring only 6 to 8 in 10 mm. as compared with 7 to 9 in the original species. This narrow elongate form increases in width very gradually and attains a width of 2.5 to 2.6 mm. in some parts of the stipe where it seems to be widened by the method of compression, and in those parts it is only about .5 mm. wider than the original species.

Thecae have slight overlap with apertures about normal to axis and angle of inclination 35° to 40°. The margins of the stipes are deeply notched and the outer edges of the apertures end in relatively sharp points.

The species *D. euglyphus* Lapworth (1880, p. 166) occurs widespread, in the Viola limestone and Stringtown shale of Oklahoma the Womble shale of Arkansas, the Normanskill shale of New York, the Athens shale of Alabama, Tennessee and Virginia, also in Maine, Quebec, British Columbia, Great Britain, and Australia.

Occurrence.—This exceptionally long new variety occurs in considerable numbers near the base of the Athens shale in a quarry 4.4 miles south of Abingdon, Virginia.

Holotype.—Graptolite collection, University of Oklahoma.

DIPLOGRAPTUS (ORTHOGRAPTUS) TRUNCATUS var. LONGITHECATUS

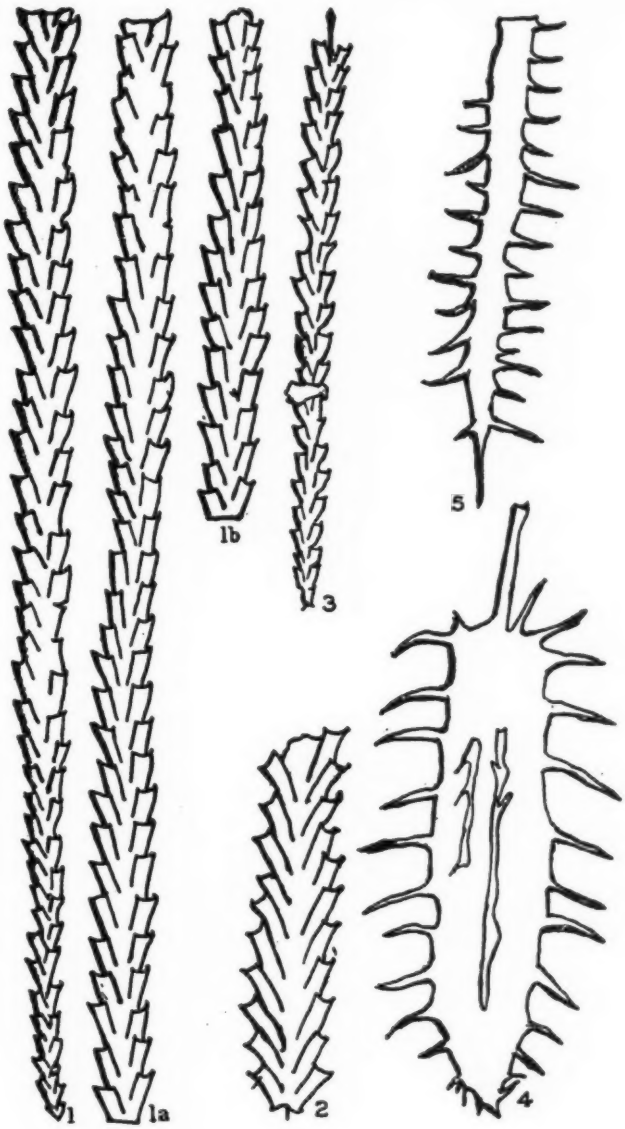
Decker n. var.
Figure 2

This is a broad short form with a length of 16.6 mm. and a width of nearly 4 mm. The distal part of the original species has about this width, but the new variety has exceptionally long thecae. They occur only 6 to 7 in 10 mm. as compared to 10 to 13 in 10 mm. for the species. The overlap is $\frac{1}{2}$ to $\frac{3}{4}$ and the angle of inclination is 35° to 40°. The thecae expand in width as they approach the apertures.

The species occurs in northern Wales, northern Ireland and in Scotland. It was described by Lapworth (1877, p. 133) in an appendix to a paper by Swanston. Elles and Wood (1901–1918, ppl 235–238) have described and illustrated four varieties of this species and Ruedemann (1947, p. 403) has described two of these varieties.

Occurrence.—The new variety was collected 200 feet above the base of the Athens shale at Clifton Heights, one mile south of Bristol, Tennessee.

Holotype.—Graptolite collection, University of Oklahoma.



(All specimens are from the Athens shale, illustrations ×3).

FIGS. *1, 1a, 1b—Diplograptus* (*Glyptograptus*) *euglyphus* Lapworth var. *elongatus* Decker n. var. (3 parts of one specimen).
2—Diplograptus (*Orthograptus*) *truncatus* Lapworth var. *longithecatus* Decker n. var.
3—Diplograptus (*Amplexograptus*) *maxwelli* Decker var. *rarithecatus* Decker n. var.
4—Glossograptus ciliatus Emmons var. *robustus* Decker n. var.
5—Glossograptus ciliatus Emmons var. *sparsithecatus* Decker n. var.

DIPLOGRAPTUS (AMPLESOGRAPTUS) MAXWELLI var. RARITHECATUS
Decker n. var.
Figure 3

This new slender variety has a length of 20 mm. and a width varying from .5 mm. proximally to 1.75 mm. distally. The increase in width occurs within 6 mm. The thecae of the variety occur only 7 to 10 in 10 mm. as compared to 10 to 14 for the species. The overlap is about ¼ and the angle of inclination 15° to 25°. The new variety has the deeply notched margins characteristic of the species.

The species was described by Decker (1935, p. 242) from beds 25 feet below the top of the Bromide formation of the Simpson group at Rock Crossing in the Criner Hills in Oklahoma. The same species was described in a paper by Decker and Frederickson (1941, p. 157) from the Mifflin member of the Platteville formation, 3.8 miles north of Platteville, Wisconsin. Also, Ekström (1936, pp. 37–39) described and illustrated this species from Sweden. He found 17 stipes associated in a synrhabdosome. However, because of its association there with *Phyllograptus*, it is thought to come from a much lower stratigraphic zone.

Occurrence.—This variety was collected from strata 3 feet above the base of the Athens shale at Clifton Heights, one mile south of Bristol, Tennessee.

Holotype.—Graptolite collection, Harvard University.

GLOSSOGRAPTUS CILIATUS var. ROBUSTUS
Decker n. var.
Figure 4

This new variety is relatively short, only 21.5 mm. long, but it has the exceptional width of 5 mm. (10.5 mm. to the ends of the spines). It has exceptionally long large thecae which occur only 4 to 5 in 10 mm. This is less than half the number (11) characteristic of the original species.

Glossograptus ciliatus Emmons is very common and occurs widespread in Canada and United States from Maine to Idaho and Washington, Oklahoma, Arkansas, New York and generally in the lower part of the Athens shale of Alabama, Tennessee and Virginia. It also occurs in Peru, Argentina and Great Britain.

Occurrence.—The new variety occurs 170 feet above the base of the Athens shale at Clifton Heights, a mile south of Bristol, Tennessee.

Holotype.—Graptolite collection, University of Oklahoma.

GLOSSOGRAPTUS CILIATUS var. SPARSITHECATUS
Decker n. var.
Figure 5

This new spinose variety has a length of 22.5 mm. with stipe incomplete. The width without spines is 2 mm. and with spines nearly 8 mm., so the spines are over 2 mm. long. The thecae are very long, occurring only 7 in 10 mm. while the original species has 10 to 11 in 10 mm. This number of thecae is the same as in the much younger *Glossograptus quadrimucronatus paucithecatus* Decker (1935, p. 703) from the Polk Creek shale of Arkansas. However, this new variety is much narrower with much longer spines.

Occurrence.—This new variety occurs 6 feet above the base of the Athens shale at Clifton Heights one mile south of Bristol, Tennessee.

Holotype.—Graptolite collection, Harvard University.

These five varieties of graptolites have been described and illustrated notwithstanding the fact that very recently Newell (1948, pp. 225–232) has argued strongly against the use of varieties in paleontologic writing and has suggested the substitution of subspecies as an infraspecific category. He contends that subspecies fit better into the plan of the study of populations revealing the process of evolution. Doubtless some groups, such as the Mollusca, may supply intergrading populations, represented by large numbers of specimens in some of our museums, but there may remain a very practical use of varieties in stratigraphic studies where extensive population material is not available.

The use of varieties in the description of graptolites has been very common in practically every country where they occur, and several varieties of a single species are not uncommonly recognized. Bulman (1927,

part 1, pp. 23–28, pls. 1, 2) has illustrated three varieties of the Cambrian *Dictyonema flabelliforme* and has listed three more varieties of that species. Elles and Wood (1901–1918, pp. 233–238) have described and illustrated four varieties of *Diplograptus* (*Orthograptus*) *truncatus*. Varieties have also been used extensively in Scandinavia, as in the work of Monsen (1937, pp. 70–73), and they have been reported in Australia by Keble and Benson (1939, pp. 75–89).

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JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 218–224, 1 TEXT FIG., MARCH 1949

PALEONTOLOGICAL NOTES

AN EDEN FAUNULE IN NEW JERSEY

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ABSTRACT—Few fossils have been found in the Upper Ordovician Martinsburg group of clastic sediments in northern New Jersey. The age of the underlying limestone is known to be Trenton. Discovery of Eden fossils in the upper part of the Martinsburg and correlation with known sequences in eastern Pennsylvania indicate its upper limit.

INTRODUCTION

The thick sequence of Ordovician clastic sediments known as the Martinsburg group extends across northern New Jersey trending northeastward into New York and southwestward into Pennsylvania. The group in Pennsylvania has been separated into an upper sandy formation, the Shochary, of Pulaski age, and underlying dark shales or slates whose age ranges from approximately middle Trenton through Eden (Willard, 1943). These units can be traced into New Jersey. In eastern Pennsylvania and New Jersey the Martinsburg has been severely squeezed, first in the Taconic disturbance near the close of the Ordovician, and later during the Appalachian Revolution. Consequently, the shales have been altered to workable slates. Westward beyond the limit of influence of Taconic orogeny, the rock remains shale. The sandy beds were little altered. The Martinsburg in New Jersey is separated unconformably from the overlying basal Silurian, the Shawangunk formation (Willard and Cleaves, 1939).

Because of the metamorphism, almost no fossils have been discovered in the slate, but in the unaltered shales to the west remains are fairly common, particularly those of Eden age which occur high in the shale. Pulaski fossils have been collected from the Shochary sandstone as far east as the slate belt of eastern Pennsylvania. The lower part of the shale carries graptolites generally called "Normanskill" (Willard, 1943).

MARTINSBURG FOSSILS IN NEW JERSEY

In 1903 Stewart Weller published lists of Martinsburg (his "Hudson River") fossils in New Jersey (Weller, 1903). Weller judged the thickness of the shales to be several thousand feet, and 3000 to 3500 seems a fair

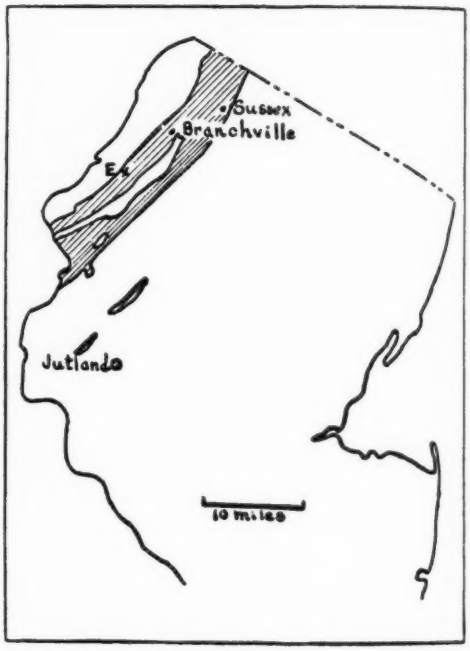

FIG. 1.—Sketch map of northern New Jersey. Martinsburg group shaded. E indicates location of Eden faunule.

estimate including the upper sandy beds whose base appears to be somewhat older than in Pennsylvania and which have lost thickness through erosion of their upper part. Weller deduced the age of the base of the Martinsburg from its position overlying the Jacksonburg limestone containing *Parastrophia hemiplicata*. Of this he wrote, "The formation may be the time equivalent, not only of a portion of the Trenton, but also of the Utica and Lorrain of the New York series" (*op. cit.* p. 50). He listed fossils from three localities.

Flagstone quarry at Sussex (*op. cit.*, p. 51), calcareous sandstone "crowded with a small variety of *Plectambonites sericeus*."
Cornulites sp. undet.
Plectambonites sericeus (Sowerby)
Plectorthis plicatella (Hall)
Dalmanella testudinaria (Dalman)

Weller commented on these as being all long-range species, and, indeed, with the exception of the *Plectorthis* the faunule might be Middle or Upper Ordovician. Three-quarters of a mile from Branchville (*op. cit.* p. 52) Weller collected from a small quarry a "short distance above the Trenton limestone," the following:

Diplograptus foliaceus (Murchison)
Diplograptus angustifolius (Hall)
Lasiograptus mucronatus (Hall)
Corynoides calycularis Nicholson
Dalmanella testudinaria (Dalman)

He called the foregoing faunule "Norman's Kill," which indeed it appears to be save for the *Corynoides* which Ruedemann 1947 assigns to the Canajoharie. Finally, Weller listed a third faunule (*op. cit.* p. 53) from along the Lehigh Valley R. R. 340 yards east of the station at Jutland. He considered its stratigraphic position indefinite, but near the base and like his second list, "Norman's Kill":

Climacograptus phyllophorus (Gurley)
Dicranograptus ramosus (Hall)
Coenograptus gracilis (Hall)
Teleograptus geinitzianus (Hall)

As in the second faunule, there seems little reason to change Wellers assignment of age, although *Coenograptus* may be post-Normans-kill (Ruedemann, 1947).

Since Weller's day, little or nothing has been added to the faunal lists of the Martinsburg in New Jersey (Lewis and Kümmel, 1904; Bayley, Salisbury, and Kümmel, 1914). However, Kümmel in the former reference cited Ulrich's opinion that the graptolites are of Trenton age.

In the fall of 1947 Meredith E. Johnson, State Geologist of New Jersey, and the writer were reexamining the Ordovician-Silurian contact eastward from the Delaware Water Gap across New Jersey. In northwestern Sussex County an unimproved road crosses Kittatinny Mountain southeastward from Faltbrookville. At a sharp elbow turn at the southeast foot of the mountain at an elevation of approximately 1080 feet, fossiliferous Martinsburg was found beneath talus blocks from the Shawangunk (basal Silurian) formation which supports the mountain. The Martinsburg here is fine grained, gray to brown, brown-weathering, non-calcareous, slightly ferruginous sandstone. From it the following fossils have been identified:*

"Crinoidea," columnals
Cornulites sp. (similar to Weller's figure, *q.v.*)
Dinorthis sp.
Sowerbyella rugosa (Meek)
Resserella multisecta (Meek)
Cryptolithus bellulus (Ulrich)

The trilobite, *Cryptolithus bellulus*, is the most abundant fossil in this faunule.

The stratigraphic position of this faunule is deduced from its geographic location in the belt of Martinsburg and from the araneceous character of the matrix to be high in the slaty portion of the sequence and the equivalent of the Eden faunules in Pennsylvania. The presence of *Cryptolithus bellulus* is the most significant element of the faunule since it is known abundantly in beds of Eden age in Pennsylvania, but not higher, and is there commonly associated with *Sowerbyella rugosa* and *Resserella multisecta*, both Eden species.

STRATIGRAPHIC SIGNIFICANCE

Because so little is known of the fossils and age of the Martinsburg in New Jersey,

* Subsequent to the discovery of the faunule, W. S. Skinner, a graduate student at Lehigh, at the request of the author visited the location and collected additional material.

SUMMARY TABULATION

Age		South Central Pennsylvania	Eastern Pennsylvania	Northern New Jersey
Silurian		Tuscarora ss.	Shawangunk fm.	Shawangunk fm.
Ordovician	Richmond	Juniata fm.	UNC.	UNC.
	Maysville	Bald Eagle cg.		
	Pulaski	Fairview ss.†	Shochary ss.	Shochary ss.
	Eden	Dauphin sh.	Slate	Slate
	Trenton	Chambersburg ls.	Jacksonburg ls.	Jacksonburg ls.

† The Martinsburg group includes: Fairview and Shochary sandstones, Dauphin shale and the slate.

any additional information is useful. In 1903 Weller (*op. cit.* p. 50) stated:

> Although the age of the base of the Hudson River [Martinsburg] formation can be determined with some degree of certainty by the faunas of the subjacent Trenton [Jacksonburg] limestone, the age of the top of the formation in New Jersey has not been determined, because of the extreme rarity of organic remains in the formation. The formation may be the time equivalent, not only of a portion of the Trenton, but also of the Utica and the Lorrain formations of the New York series.

Weller's conclusions may now be amplified. The upper age limit of his "Hudson River" slate is Eden, and the beds carrying the Eden faunule are followed by younger sandstone of probable Pulaski age.

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COMMENTS ON PALEOGEOGRAPHY AND NOMENCLATURE

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Under the title *Paleogeography and Nomenclature*[1] Eugene S. Richardson, Jr., recently has contributed an interesting discussion of certain common prejudices in paleontology with respect to geographic and stratigraphic ranges of species and genera. He shares with others the belief that many species and genera individually masquerade under more than one name because of traditional stratigraphic and geographic bias on the part of paleontologists. He says,

> There are many instances of widely ranging species where recognition is obscured by the fact that they bear different names in different parts of the ranges. . . . Only too often a species is regarded as new because it is found in a new locality and because the published pictures of closely related (and possibly identical) forms look somewhat different due to imperfect preservation, or to imperfect photographic reproduction. . . . Suppositions that the geographic and stratigraphic range are limited should in all cases be proven by reference to actual specimens. . . . A related error, even more difficult to uproot from the literature after publication, is that of anticipating a change in the generic constitution of a fauna at a system boundary by applying different generic names on each side of the "break."

Many paleontologists undoubtedly have recognized and given thought to the points enumerated by Richardson and they will

[1] Jour. Paleontology, vol. 22, pp. 369–370, 1948.

applaud his desire to arrive at the facts of fossil distributions. The assertions, quoted above, are in some cases quite valid, although it is debatable whether or not "reference to actual specimens" can prove definite limits in horizontal and vertical ranges. Absolute ranges seldom, if ever, can be determined in paleontology.

The greater part of Richardson's paper is devoted to the citation of an interesting example of a trilobite species believed to have a remarkably long geographic distribution in a north-south direction, *meridional range* of zoogeographers. The purpose of the present discussion is to analyze certain aspects of Richardson's conclusions which bear importantly on general problems in paleontology.

Richardson announces the discovery in Newfoundland of a south Andean trilobite species of Early Ordovician age, *Parabolina andina* (Hoek). The Newfoundland area is separated by about 70° of latitude, including the currently broad tropical belt, from the Southern Andes of Bolivia and Argentina whence the species originally was reported. For an overwhelming majority of living invertebrates the tropics constitutes an effective barrier to migration between the temperate zones. And the great oceanic streams generally flow tangentially with respect to the equator. We may agree with Richardson that "it is a matter of some surprise to find that a trilobite species in the early Ordovician sea had such a wide geographic range." But the alleged meridional range is much more remarkable than would be an equally great east-west distribution.

Identification of the Newfoundland specimens was accomplished by direct comparison with authentic South American material. Furthermore Professor Horacio J. Harrington, authority on the Ordovician in Argentina, concurred in Richardson's identification of the Newfoundland specimens after examining photographs sent to him by Richardson. While awaiting documentation and comparison of the characters of the Newfoundland and South American specimens in formal description there is no basis for passing judgment on the correctness of the identification. There is no indication, however, that quantitative methods were employed. The prime purpose of this note is to stress the remarkable nature of this range providing, of course, that the Newfoundland material is correctly identified; and to point out that great horizontal ranges crossing the equator in a meridional direction probably are not common in the fossil record.

As indicated by Richardson, it has been common practice for paleontologists to use separate specific names for closely similar species of different continents. For the most part this practice is conservative and defensible. In general, there are two reasons for it. For one thing commonly it is difficult or impossible to obtain well preserved authentic specimens from another continent for direct comparison, and, frequently, published descriptions and illustrations are not alone sufficient for reliable identification of a given species. Certainly, poorly documented and unsubstantiated extension of geographic ranges on an intercontinental scale is less conservative than the frank use of two names for what cannot readily be demonstrated to be a single species.

Existing attitudes in marine invertebrate paleontology are in part derived from the accumulated data of marine zoogeography. Except for certain Protozoa and Arthropoda there are remarkably few truly cosmopolitan species of living invertebrates. Generally widely ranging forms are limited either to the northern or to the southern hemisphere. An overwhelming majority of species are confined to single faunal realms, and in general these faunal realms lie mainly in areas north or south of the equator. Thus while many species within a realm occur along both eastern and western shores of an ocean basin, an infinitesimal proportion of the total number range far north and south of the equator.

Commonly living species and whole faunas in the sea are restricted to regions limited by land barriers and defined by marine climate. Although there are grounds for concluding that climatic zones have not always been in the geologic past so well defined as now, it is probable that the earth always has been broadly differentiated by east-west belts of climate. There are in fact relatively few species which exhibit broad limits of tolerance to temperature and these forms generally have great bathymetric and horizontal ranges. With the exception of

these few forms the great majority of species and even very many genera of marine invertebrates have a relatively limited meridional range as compared with the east-west range. According to Ekman[2] unique conditions are found along the *west* coasts of Africa and the Americas. These conditions are produced by ocean currents which parallel the continental margins for enormous distances in a meridional direction thus tending greatly to reduce the effect of latitude on the climates. Here alone on the entire earth do littoral benthonic animals generally possess great meridional ranges. Even here, however, the ranges tend to terminate near the equator and the majority of species that live at high latitudes do not range far into tropical latitudes.

Ekman (op. cit., p. 319) cited two species of starfish which have enormous meridional ranges. These extend across the equator into arctic and antarctic waters. *Mytilus edulis*, a pelecypod, has a similar great range. Compared with usual ranges, however, these are quite extraordinary. He also (op. cit., pp. 327–328) summarized the scanty knowledge available on a rather poorly understood group of species which are reported only from the cold waters at high latitudes. These so-called *bipolar species* include a few radiolarians, sponges, hydroids, polychetes, and other annelids, amphipods, isopods, schizopod Crustacea, Mollusca, etc. It is believed that the bona fide bipolar species, that is, species common to the two polar areas and unknown in intermediate areas, ultimately will be found in the deep cold waters at low latitudes. These forms probably are truly cosmopolitan within their habitat.

From the study of marine zoogeography it might be inferred that European and north Asiatic species probably are common in the fossil record of North America. Many of these might, of course, properly be referred to separate subspecies. Fossil species common to North and South America probably are rare, except under the special conditions that apply to the western borders of the continents, that is, if geographic ranges are comparable to those of living species. In those western areas fossil faunas with many species in common to the two continents probably occur. One example is the far flung Early Permian faunas of the Andes which compare very closely with those of the same age in Texas.

"Cosmopolitan" species have been reported from every geologic system. Experience shows that refined studies tend to reduce the geographic ranges of many of these species. Almost all living species differentiate into geographic races, or subspecies, as they extend their ranges. This is so nearly universal, save for a few exceptions, that we may confidently look for the same phenomenon throughout the fossil record. Hence, in the truly wide ranging species there very likely are several distinctive geographic subspecies.

A number of widely ranging "species" might be cited from the fossil record of marine invertebrates. For instance, the Triassic pelecypod *Pseudomonotis ochotica* Keyserling has been reported well south and north of the equator in both the eastern and western hemisphers. It is true, of course, that these fossils are closely similar in many widely separated localities. But reference to present day distributions strongly suggests that the resemblances may be generic rather than specific. Other so-called cosmopolitan forms are found among brachiopods, ammonites and graptolites.

Few if any of these "cosmopolitan" fossil species have been subjected to quantitative studies. Hence the precise degrees of similarity and difference in various parts of the geographic range are in final analysis unknown, and interpretations necessarily are based on the most unsatisfactory kind of evidence which is almost wholly qualitative. It is true also that quantitative methods have played a very minor role in differentiation of species and races of living invertebrates. Here, however, the problem is immeasurably simpler than with fossils because numerous kinds of evidence available for living animals are lost in fossils.

Returning to *Parabolina andina* it is, of course, possible that this species is one of the few exceptional invertebrates with a great meridonal range. The special aspects of the problem, however, call for considerable care and for confirmatory evidence. For instance: Do the statistical modes for the most

[2] Ekman, Sven, *Tiergeographie des Meeres*, p. 316, 1935.

critical characters closely correspond in reasonably adequate samples from Newfoundland and Argentina? Are there other associated species common to the two areas? Is it possible that the close resemblance between the Newfoundland and South American samples may be fortuitous, or simply the resemblance ordinarily found between two allied species within a single genus?

THE VALUE OF GLOBIGERINIDAE RATIOS IN STRATIGRAPHY

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ABSTRACT—Examples are given of the frequency ratios of the genera *Globigerina*, *Globigerinella*, *Globigerinoides* and *Orbulina* in the Miocene sections of Egypt and southern Turkey. These ratios are characteristic and can be used for local correlations.

The great vertical distribution of the Globigerinidae often results in an underestimation of the value of this family as index fossils in correlation work. In reality they can be of great value for differentiating between the Senonian and Eocene and between the Lower, Middle, and Upper Miocene.

The main representatives of the family Globigerinidae in the Middle East are the genera *Globigerina*, *Globigerinella*, *Globigerinoides* and *Orbulina*, of which the latter two are typical Neogene forms. *Globigerinoides* first appears in the Upper Eocene. *Orbulina* does not occur below the Oligocene and for all practical purposes it is an index to Miocene or younger strata because Oligocene forms are uncommon.

Globigerinid ratios in Egypt

Both *Globigerina* and *Globigerinella* are common genera in the Senonian and Eocene, but accurate quantitative analyses (1) of their occurrence in many Cretaceous sections of Egypt, Sinai (2) and southern Turkey (Arabian facies) (3) have shown that the ratio of their relative abundance is very characteristic. In the Campanian and Santonian of Egypt *Globigerinella* usually greatly predominates. In the Maestrichtian the frequencies are about equal and either one or the other may be slightly more abundant. In the basal Eocene, however, a complete reversal occurs and *Globigerina* is conspicuously predominant. This relationship remains unchanged into the Miocene which witnessed the main development of the Globigerinidae.

The Lower, Middle and Upper Miocene can often be distinguished by accurate analysis of the relative abundances of the four above mentioned genera. One of the principal characteristics of the Miocene of Egypt, and particularly of the Middle Miocene, is the enormous richness in Globigerinidae. In a 100 gram sample collected at Gebel Zeit (about 250 kilometers southeast of Suez) the writer counted 1,492,416 Globigerinidae, i.e., about 30,000 per cubic centimeter or rock or about 24% of the rock volume (the average size of the Globigerinidae being about 0.2 mm). Also the ratios between the genera are characteristic for the Middle Miocene. In a Miocene section west of Abu Shaar (320 kilometers southeast of Suez) the following rations (in %) were found:

Upper Miocene:
Globigerina: 62–97% (of all Globigerinidae)
Globigerinella: 2–17%
Globigerinoides: 4–15% (mainly <10%)
Orbulina: 0.5–10.4% (mainly <2%)

Middle Miocene:
Globigerina: 60–90%
Globigerinella: 3–20%
Globigerinoides: 7–22% (mainly >15%)
Orbulina: 0.5–1.4%

Lower Miocene:

Globigerina: 40–45%
Globigerinella: 19–29%
Globigerinoides: 25–40%
Orbulina: 0.3–4.5%

Although the percentage of *Globigerinoides* in this Middle Miocene sample is lower than in the Lower Miocene, the total number of individuals is much larger in the Middle Miocene as the total number of Globigerinidae exceeds that of the other units.

Near Wadi Dara (about 200 kilometers southeast of Suez) a Middle Miocene well section furnished the following ratios: *Globigerina* 65–81%, *Globigerinella* 4–19%; *Globigerinoides* 7–15% (mainly 10%); *Orbulina* 3–4%.

On the west flank of Gebel Zeit (250 kilometers southeast of Suez) a basal Pliocene and Middle Miocene marl section was studied. The Middle Miocene shows the following ratios: *Globigerina* 56%; *Globigerinella* 13%; *Globigerinoides* 30%; *Orbulina* 0.3%. The basal Pliocene has completely different corresponding ratios: 91%; 0.9%; 6.9%; 0.8%.

In the marly non-sandy Miocene facies of the Red Sea area the following rules seem to be valid for the Globigerinidae:

1) The total number of Globigerinidae is largest in the Middle Miocene and decreases in the following order: basal Pliocene, Upper Miocene (where not developed as a non-foraminiferal solid anhydrite series) and Lower Miocene. In all four groups, however, the Globigerinidae are very abundant.

2) *Globigerina* is the dominant genus in all four stratigraphic units, but it increases from 40% in the Lower Miocene to over 90% in the basal Pliocene. *Orbulina* is the most infrequent genus and generally constitutes less than 1% of the specimens.

3) *Globigerinella* percentages (not their total number) also decrease from the Lower Miocene to the basal Pliocene but this decrease is less rapid than with *Globigerinella*. In the Lower and Middle Miocene *Globigerinoides* commonly is more abundant than *Globigerinella*.

Globigerinid ratios in Turkey

In the Adana region of southwestern Turkey a marly Miocene section almost 6000 meters thick is developed, which was studied in 1943 by the method of quantitative generic analysis (1). This section differs from most of the Red Sea sections by its great thickness and the occurrence of many thin sandstone intercalations.

The Globigerinidae of the Middle Miocene show the following characteristics:

1) There is a characteristic faunal drop from the Middle to the Upper to the Lower Miocene.

2) *Globigerina* is the dominant genus.

3) Both *Globigerinella* and *Orbulina* are rare. They constitute only 0–5% of the Globigerinidae in the samples.

4) *Globigerinoides* is abundant and in many samples is almost as common as *Globigerina*.

The Lower Miocene in Turkey, being usually developed in an unfavorable sandy facies, is much less fossiliferous than in Egypt and therefore no characteristic ratios could be established. The total number of Foraminifera decreases so much in the Lower Miocene, that only one or two specimens of *Globigerinella*, *Globigerinoides* or *Orbulina* may be present in a sample and commonly they are completely absent.

These data show certain differences between the ratios in Egypt and Turkey but in similarly developed sections (for example the Middle Miocene) considerable similarity exists. The correlation of Miocene beds by globigerinid ratios is therefore primarily useful in local areas, but if used with care, this method may also give important information of more regional nature.

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NOMENCLATURAL NOTES

REVISION OF THE INTERNATIONAL RULES OF ZOOLOGICAL NOMENCLATURE

Because it is judged that paleontologists generally will be interested in revision of the International Rules of Zoological Nomenclature authorized at the Paris meeting of the International Congress of Zoology, recent correspondence on this subject is here published.

Letter from R. C. Moore to Francis Hemming, Secretary of the International Commission on Zoological Nomenclature

Dear Mr. Hemming:

From various sources members of the Joint Committee on Zoological Nomenclature representing the Paleontological Society, Society of Economic Paleontologists and Mineralogists, and the Society of Vertebrate Paleontology in North America have heard reports of action taken at the Paris meeting of the International Zoological Congress, adopting a revised code of *Règles* subject to some revision of wording and entrusted to you with advice from "jurists."

In some quarters, there is disposition to register violent protest against this action. Before joining in such protest, our Policy Board and the Committee would like to be better informed of pertinent facts. If emendation of the *Règles* is an accomplished fact through action of the Congress, seemingly the only course open to zoological workers is to follow the new rules or ignore them and perhaps seek alteration in a legal manner at the next meeting of the Congress. Is this view correct?

American zoologists, including paleozoologists, are not likely to be uncritical of a revised set of rules having ambiguities or what they think are obvious defects. It is my personal judgment that revision can be done most effectively by some one person who thoroughly understands principles to be incorporated and this person should be the permanent secretary, but I also think that review by competent committee such as the Commission is needful before publication makes the rules presumably effective. It is doubtless unnecessary to add that your responsibility is a heavy one.

Thanking you for advice, I am

Very truly yours,
Raymond C. Moore, Chairman
For the Joint Committee on
Zoological Nomenclature,
Policy Board
December 21, 1948

Mr. Hemming's reply on revision of the Règles *at the Paris Conference*

Dear Mr. Moore:

Thank you very much for your letter of 21st December on the above subject which I received this morning. I am grateful to you for writing to me on this subject, for it is evident that there is a certain amount of misunderstanding about the action taken at Paris on the part of workers who were unable to attend that meeting.

As I explained both at Ottawa when I attended the annual meeting of the Paleontological Society a year ago and during the similar discussions which I held at Washington, Chicago and New York during my visit to your country last Christmas, it was very evident from the communications which before leaving England I had already received from zoologists and palaeontologists in all parts of the world that there was widespread feeling among active workers that the International Code of Zoological Nomenclature was out of date and inadequate in many respects. It was equally evident that many workers felt that this was due to the lack of initiative on the part of the Commission over a long period, for, although the Code was nearly fifty years old, no serious attempt had ever been made by the Commission to remedy the serious defects or to remove the obvious obscurities in the Code, defects and obscurities which—as we all know from our own experience—have greatly impeded systematic workers when preparing papers on subjects involving the use of scientific names. For my part, I agreed with both these criti-

cisms and considered it most important that, if it were possible, effective action should be taken at the meeting of the International Congress of Zoology arranged to be held in Paris in July this year.

If this object were to be attained, there were, it was evident, a number of important preliminary problems which would need to be solved. The first was to ascertain as fully as possible the general wishes of active workers in all parts of the world, the second to ensure that the point of view of American workers should be adequately represented, notwithstanding the fact that the high cost of travel and similar considerations might lead to American participation in the Congress being relatively less than that of some of the European countries situated near the seat of the Congress. These considerations led me to accept with particular pleasure the invitation which I received in the autumn of 1947 that I should visit America the following Christmas for the purpose of discussing current problems of zoological nomenclature particularly those likely to be raised at the Paris Congress, with leading specialists at the Smithsonian Institution, Washington and at other important centres. In this way I was enabled to hold extensive and detailed discussions not only at Washington, but also at Chicago (during the annual meeting of the American Association for the Advancement of Science), at Ottawa during the corresponding meeting of the Paleontological Society and in New York, at the American Museum of Natural History. These discussions enabled me to gather the views of a large and representative cross-section of opinion among American workers. The opportunity so presented was of the greatest value, for it made it possible for me to judge the outlook of American specialists on all the principal subjects affecting the Code which required consideration at Paris. In the light of these discussions, I felt confident that, in my capacity first as Secretary to the Commission and second as President of the Section on Nomenclature (a post which had already been offered to me by the Organizing Committee of the Paris Congress), I should be able to exercise an influence sufficiently strong to ensure that no decisions on which controversy might arise at the Congress were taken in circumstances in which American opinion was inadequately represented.

Fortified by the knowledge and experience gained by my visit to America, I determined to do everything in my power to secure the adoption in Paris of the reforms in the Code which were both urgently necessary and keenly desired by the general body of zoologists and palaeontologists. The opportunity presented by that Congress was clearly one which should not be missed, for thirteen years and a World War had passed by since the last meeting of the Congress and the general outlook was such that no man could say with certainty when the next Congress would be held after that in Paris in 1948.

The duration of a scientific international congress is so short that, unless a great deal of preparatory work is done in advance of the meeting, there is no chance of securing proper consideration of a large number of detailed proposals on so complicated a matter as the reform of the Code. It was for this reason that I decided to submit to the Commission and the Congress in Paris a series of detailed memoranda dealing with each of the principal questions requiring attention. This represented a complete break with the past practice of the Commission but I had no doubt that it was the right course and the only one which would enable members of the Commission and members of the Congress attending the meetings of the Section on Nomenclature adequately to inform themselves of the nature of the issues involved before taking part in the discussions on the proposals submitted. This procedure proved of the greatest value, providing, as it did, an opportunity for members of the Congress to make constructive suggestions for the modification or extension in one direction or another of the proposals submitted. Those proposals were based upon the representations addressed to the Commission prior to the opening of the Congress, supplemented in many directions by information regarding the attitude of American zoologists and palaeontologists gained during my visit to your country. The representative character of the proposals submitted to the Commission and the Congress in Paris accounts, no doubt, for the ready acceptance which in the main was accorded to those proposals. The

fact that in a number of cases improvements in matters of detail were introduced into these proposals in the course of the Paris Congress is to be attributed to the care taken to provide adequate opportunity for detailed discussion, before either the Commission or the Congress were asked to take decisions.

In another important respect the procedure adopted at Paris represented a break with past practice, a break made deliberately in order to bring the general membership of the Congress and the members of the Commission into the closest possible relationship with each other. This was the decision to hold all the meetings of the Commission in public and to invite members of the Congress attending those meetings to take an active part in the discussion of each proposal brought forward. This procedure had the great advantage that it provided two opportunities for the discussion of every proposal for the amendment of the Code, the first at the meeting of the Commission, the second at the meeting of the Section on Nomenclature at which the proposals of the Commission were brought foward for approval. In actual practice, under this procedure, there was very little difference between the attendance at most of the meetings of the Commission and that at meetings of the Section, and the discussion at the former was so thorough that it was not found necessary in most cases to spend any great amount of time in going over the same ground in the Section.

The decision to hold the meetings of the Commission in public had the further advantage that, although the number of American zoologists attending the Congress was inevitably much smaller than that of European zoologists, the interest shown by American zoologists in questions of nomenclature was such that at the meetings of the Commission—as also of the Section on Nomenclature—there were more American zoologists present than there were zoologists of any other single country. The American representation so secured was amply sufficient to enable objections to have been raised if any of the proposals brought forward had run counter to the general wishes of American zoologists. In actual fact, however, the proceedings were extremely harmonious and no objections of this kind were advanced, every decision in regard to the Code being taken unanimously. I should perhaps add that in one or two matters some of the zoologists present showed a disposition to seek decisions in cases where (as I knew) sufficient preparatory work had not been carried out (as, for example, the scope of Article 19 and the question of the acceptance of neotypes, both subjects, as I was aware, in which American zoologists were much interested) or where (as in the case of the relative importance to be attached on the one hand to established nomenclatorial practice and on the other hand to the Law or Priority) where, as I was aware, American opinion was divided and insufficient material was available to enable a generally acceptable solution to be found. In every such case I used my authority as President of the Section to prevent a definite decision from being taken, it being agreed that these matters should be closely studied before the next meeting of the Congress, in consultation with all interested specialists, with a view to the submission by the Commission of a comprehensive report with recommendations as to the action to be taken.

The Official Record of the Proceedings of the Commission during its Paris Session, containing a detailed record of all the conclusions reached during the Congress, will be published in the Commission's "Bulletin of Zoological Nomenclature," as soon as it is available. At the same time there will be published in the "Bulletin" both the text of the detailed memoranda submitted to the Congress (to which I have already referred) and also a full account of the Proceedings of the Section on Nomenclature. Everything possible is being done to press forward the publication of these documents, for, as the Commission realized in Paris, no balanced judgment on the work achieved in Paris can be formed until these documents are available for study.

Quite apart from these considerations, there is another very important reason why it is very desirable that the official record of the decisions taken in Paris should be made available as soon as possible. For until this is done, it will not be possible to make a start with the task of giving practical effect to the Paris decisions by incorporating them in the Code. On this, I should explain that

the Congress, at the recommendation of the Commission, agreed at the outset to concentrate their attention upon the task of reaching clear-cut decisions on all the questions affecting the Code that were brought before them and to leave to expert Jurists the highly technical professional task of preparing the requisite French and English texts to be inserted in the Code. This decision was obviously a wise decision, both because zoologists cannot be expected to possess the special qualifications necessary for this type of drafting and because, if the Commission and the Congress had attempted itself to undertake the task, they would have been able to carry through only a very small part of the programme which they did in fact complete.

The Commission and the Congress realized however that, while the jurists possessed a skill not possessed by zoologists and could therefore prepare a much more satisfactory text than they could themselves have prepared, zoologists had themselves a most important role to play before the task of giving effect to the decisions reached in Paris was completed. This is the scrutiny from the zoological point of view of the revised text of the *Règles* when made, for the purpose of ensuring that the text so prepared corresponds with, and gives effect to, the decisions taken in Paris and that in no respect it either goes beyond those decisions or falls short of those decisions. It was agreed in Paris that this scrutiny should be undertaken by the members of the Commission, including Alternate Members of the Commission, who attended the Paris meeting, and that in addition those members of the Commission who for one reason or another did not attend that meeting should be asked to examine the draft prepared by the jurists for the purpose of examining that text from the same point of view. Finally it was agreed that the task of examining comments received in this way should be entrusted to an *ad hoc* Editorial Committee consisting of three members of the Commission who were present in Paris and that, having done so, that body should be responsible for authorizing the promulgation of the revised text of the Code. This procedure, as you will realize, follows the precedent set by the action of the Congress in Berlin in 1901, when the editing and promulgation of the present Code, as agreed upon at that meeting, was entrusted to a similar committee. As regards the present committee, it was agreed that it should consist of one European zoologist who was equally familiar with both French and English, one American zoologist and the Secretary to the Commission. The Committee so constituted consists of Professor V. van Straelen (Belgium), Professor Robert L. Usinger (U. S. A.) and myself. It was agreed that the revised text of the *Règles* should come into effect immediately upon its being promulgated in accordance with the procedure described above.

The work of the Paris Congress represents a great effort on the part of all concerned to provide the zoologists and palaeontologists of the world with an International Code of Zoological Nomenclature revised in accordance with the general will. It would be unreasonable to claim that this revision is, or that any possible revision could be, perfect but the revision now carried through deals with so many matters on lines which command general agreement and fills in a common sense manner so many obvious gaps in the present Code that it will certainly provide a text greatly superior to that now in use. We know however that it will contain some omissions—for, as I have explained, certain matters have been reserved for further consideration at the next meeting of the Congress. It must be expected also that it will contain some provisions which it may later be generally desired to modify. If this proves to be the case, such blemishes can as you suggest be removed at the next meeting of the Congress.

Quite apart from the improvements introduced into the Code by the new provisions agreed upon in Paris in regard to subjects for which there is at present no provision or for which the existing provision is ambiguous and obscure, the revised text of the Code will serve an invaluable purpose in that, by codifying the interpretative "Opinions" rendered by the Commission, it will sweep away the vast cobweb of uncertain case law which has accumulated over the last 40 years. For the first time within living memory zoologists and palaeontologists will have in their hands a single volume containing a complete statement of the stage

reached in the development of international law in the field of zoological nomenclature. Armed with this volume, workers will be able to take stock of the position in a way which is quite impossible today, and, having done so, will be able to make constructive suggestions for the further improvement of the Code. Such a re-examination of the position will be extremely valuable and it is much to be hoped that it will be undertaken both by groups of zoologists and palaeontologists and by individual specialists. Proposals so put forward will be welcomed by the Commission by whom they will be most carefully considered with a view to their being considered at the next meeting of the Congress.

In the meanwhile the promulgation of the revised text of the Code in accordance with the decision taken in Paris will be of great practical assistance to specialists in the course of their day-to-day work. For in the revised Code they will find clear-cut straight forward answers on many questions which today are the subject of argument and debate, including questions such as the interpretation of the expression "indication" as used in relation to generic names in proviso (a) to Article 25 (a problem on which the Commission is much indebted to the Joint Committee on Zoological Nomenclature in Paleontology in America). The removal of doubts and ambiguities in regard to important matters of this kind will enable workers to go forward with monographs and papers with a clear knowledge that the line which they are taking is not only in accord with common sense but in harmony also with the requirements of the Code.

Very truly yours,
Francis Hemming
December 28, 1948

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 230–233, MARCH 1949

REVIEWS

BRACHIOPODA AND MOLLUSCA FROM THE PRODUCTUS LIMESTONES OF THE SALT RANGE, by F. R. Cowper Reed. Memoirs of the Geological Survey of India, Palaeontologia Indica, New Series, Vol. XXIII, Memoir No. 2, dated 1944, possibly published in 1945 or 1946. Pp. i–xiv, 1–678, plates I–LXV. Price 63 rupees, 2 annas or 4 pounds, 16 shillings.

The monumental work of Waagen and his associates on the Permian fossils of the Salt Range was published between 1879 and 1886 and has long been a classic in the field of Paleozoic paleontology. Little has been added to the original work by subsequent writers. In 1931, Reed described some additional forms, and in the present memoir he presents the results of six years of study of new collections.

The bulk of the volume consists of systematic paleontology. Reed proposes the enormous total of 135 new species and 129 new varieties of brachiopods, 31 new species and one new variety of lamellibranchs, 18 new species and one new variety of gastropods, and 12 new species of cephalopods. New names of higher systemic rank are: *Bilotina*, new subgenus of *Strophalosia*, with a new species its sole representative; *Haydenella*, new subgenus of *Productus*, proposed to replace *Thomasia* Fredericks, which is preoccupied, subgenotype *Productus kiangsiensis* Kayser; *Purdonella*, new subgenus of *Spirifer*, proposed to replace *Munella* Fredericks which is preoccupied, subgenotype *Spirifer nikitini* Tschernyschew 1902; *Mansuyella*, new subgenus of *Spiriferina*, proposed to replace *Maia* Fredericks which is preoccupied, subgenotype *Spiriferina ornata* Waagen; *Paraspiriferina*, new subgenus of *Spiriferina*, with a new species as subgenotype; *Palaeolecanites*, new genus of ammonoids, proposed to receive a new species; and *Blanfordinia*, new genus of lamellibranch, genotype by original designation *B. lunwalensis*, a new species. *Blanfordinia* is a strict synonym of *Cyrtorostra* Branson 1930, which has a genotype from the Phosphoria formation of Wyoming.

Reed has done a vast amount of work in describing the elements of this varied fauna, and he has searched widely in the literature for comparative forms. The plates are numerous, well reproduced, and the figures are for the most part not seriously retouched. The work is marred to an inexcusable extent, however, by Reed's willingness to erect new species and varieties upon insufficient material. The form named *Rhynchotetra? dubia* n. sp. seems to the reviewer to be a fragment of *Meekella? punjabica*. Large numbers of new names are applied to forms represented by single specimens, in many cases by single valves or even fragments or worn specimens. Of the first 23 new forms, 8 are stated to be founded upon single specimens.

Rather curiously, Reed uses the spelling *Derbya*, although Waagen's original spelling is *Derbyia* and the incorrect form is a long-standing error of American paleontologists. He uses both *Paeckelmannia* and *Dienerella*, although *Paeckelmannia* is a new name for *Dienerella* Reed 1931, preoccupied. Nearly all varietal names are placed in the form of the feminine gender, regardless of the gender of the genus and subgenus. The remarks abound in such phrases as "seems almost indistinguishable from our form," "is a closely allied or identical variety," "is probably very closely allied to our new species, if not identical with it," and then Reed makes his specimens the basis of new names. There is surely little excuse for the minute taxonomic splitting indulged in by the author, and in that respect his memoir will be a continual source of nomenclatorial difficulties.

In a short stratigraphic summary, the author concludes that there is little reason to subdivide the Productus limestones, and that the differences in fauna between the units as now delimited are a matter of facies. He recognizes four elements in the fauna, the endemic, the boreal, the Pacific, and the European. The Pacific phase is dominant in the Lower Productus limestone, with a considerable boreal element. The Middle and Upper Productus limestone

contains a boreal fauna with a large endemic representation. Reed reaches no particular conclusions as to the age and correlation of the fauna other than that he believes it to be entirely Permian.

Dr. Reed is to be congratulated, never the less, upon the extent of his researches into the abundant material and upon the wide choice of comparative forms, as well as upon the quality and number of his figures.

CARL C. BRANSON

FORAMINIFERA IN THE GULLMAR FJORD AND THE SKAGERAK, by Hans Höglund. Zoologiska bidraö från Uppsala, Band 26, Appelbergs Boktryckeriakiebolag, Uppsala 1947, pp. 1–328, pls. 32, figs. 312, maps 2, tables 7.

This magnificent monograph on a part of the Recent Foraminifera of the Gullmar Fjord and the Skagerak on the Swedish coast, deals with 13 families: Astrorhizidae, Rhizaminidae, Saccamminidae, Hyperamminidae, Reophacidae, Ammodiscidae, Lituolidae, Textulariidae, Verneuilinidae, Valvulinidae, Trochamminidae, Placopsilinidae, and Buliminidae. Although it deals only with Recent Foraminifera, this work will be of the utmost importance and interest to every micropaleontologist as the author has given here an enormous amount of systematic, taxonomic, and structural data on many genera and species hitherto insufficiently well studied. It is a detailed study of 133 species. There are 4 new genera and 55 new species and varieties described. Several hundred or even thousands of numerous species were examined and measured in all details, and diagrams are presented showing individual variations, etc. The taxonomic confusion in genera such as *Reophax* and *Ammodiscus* is thoroughly examined, and numerous new species are established. A new genus, *Labrospira*, characterized by an interio-areal aperture, is separated from *Haplophragmoides* which is restricted to forms with interio-marginal apertures. A second new genus, *Ammoscalaria* is erected for *Ammobaculites*-like Foraminifera with secondary chamber-formation, whereas *Ammobaculites* has only primary chambers. *Morulaeplecta*, another new genus, is erected for arenaceous forms with swollen initial end, composed of six or seven chambers surrounding the proloculus on all sides, giving the impression of a morula, followed by a biserial part. The genus *Robertina* is split into two genera, *Robertina* s.s., with simple main apertures and relatively simple internal structure, and the new genus *Robertinoides*, with double main apertures and complicated internal structure. The author made a detailed study of the rather complex structure of the so called internal tube and the apertural characters of several species of the buliminid genera *Bulimina*, *Globobulimina*, *Bolivina*, *Loxostomum*, *Uvigerina*, and *Angulogerina*.

In the last part a brief survey is presented of the occurrence of the species within the area investigated, regarding depth, etc. The report is illustrated with 308 pen and ink drawings showing many details of the species discussed, and 32 plates of beautiful shaded drawings.

It is a great pleasure to look at these skillfully executed plates which show a rare artistic talent. This monograph is undoubtedly one of the best contributions to our knowledge of Recent Foraminifera published during the past 25 years, and every micropaleontologist will await with impatience the second part which will deal with the other families and present the ecologic results of the author's investigations.

A. TEN DAM

REPARTITION STRATIGRAPHIQUE DU GENRE ARENOBULIMINA CUSHMAN, by N. Grekoff. Revue de l'Institut Francais du petrole, vol. 2, no. 10, 1947, Ed. J. B. Bailliere et Fils, Paris, pp. 491–509, text figs. 3, pls. 2, tables 3.

This monograph on the genus *Arenobulimina* gives the original description and refigures all known species. The systematic part is therefore almost identical with the previously published monographs by Cushman (Monograph of the Foraminiferal Family Valvulinidae, 1937, and Supplement to the Monograph of the Foraminiferal Family Valvulinidae, 1947). It is not clear why the author duplicated these publications. Only one species was not previously considered by Cushman: *Arenobulimina murchisonae* (d'Orbigny) 1840,

recognized as an *Arenobulimina* by Kalinin (1937). The systematic part is followed by a useful key for the identification of species and the last four pages present a stratigraphic and geographic account of the genus *Arenobulimina* and proves the usefulness of its species as index fossils for the Cretaceous. The figures are pen and ink copies of the original illustrations.

A. TEN DAM

THE SWEDISH PALEOCENE AND ITS FORAMINIFERAL FAUNA, by Fritz Brotzen. Sveriges Geologiska Undersokning, Arsbok 42, no. 2, Kungl. Boktryckeriet P. A. Norstedt & Soner, Stockholm, 1948, pp. 1–140, pls. 19, figs. 41, table; 4 kroner.

This is the second in a series of important monographs on Swedish fossil Foraminifera. The first, issued in 1935, dealt with the Lower Senonian forms. The second is concerned with the Swedish Paleocene and its Foraminifera. One hundred and seventeen species are described and figured, of which 48 are new, and two new varieties are recognized. Four new genera and one new subgenus are described.

The new genus *Ataxophragmoides* of the family *Valvulinidae* is closely related to *Ataxophragmium* Reuss but is distinguished by undivided chambers and the lack of a uniserial stage. It differs from *Ataxogyroidina* Marie 1941, by its simple wall without septae extending into the chambers and by its elongate rounded interio-marginal opening without ramifications. The genotype is *A. frankei* Brotzen 1948, new name for *Bulimina variabilis* Franke 1927 (*non* d'Orbigny 1840).

The new genus *Høglundina* is erected for species hitherto included in *Epistomina*. The genotype is *Rotalia* (*Espistomina*) *elegans* d'Orbigny. This genus was separated on the basis of the apertural characters of Terquem's genotype, which was figured showing a lateral aperture. I have examined numerous French and English Jurassic specimens, but have never observed apertures of the peculiar rounded lateral type figured by Terquem (1883) for his *Epistomina regularis* and other Jurassic species. Macfadyen (1935) who examined the Terquem collection at Lille, France, concluded that the apertures were badly figured and that actually these specimens have normal latero-marginal apertures like those of later *Epistomina*. Several peculiar forms from the Jurassic described by Terquem as *Epistomina* seem to belong to the genera *Reinholdella* and *Asterigerina*. Until Terquem's types, and particularly that of *Epistomina regularis* are carefully restudied, it seems hazardous to erect a new genus for the characteristic later types of *Epistomina*, especially as Terquem considered these to be congeneric with his Jurassic forms.

The new genus *Pninaella* is erected for peculiar trochoid forms with an abnormally large aperture and almost complete reduction of the septae. Brotzen refers this genus very doubtfully to the Epistominidae. Only two species of the genus are known: *Pninaella scanica* n. sp., the genotype, and *P. nitidula* (Chester) 1890.

The new genus *Reinholdella* is erected for *Asterigerina*-like forms with umbilical and interio-marginal apertures and an inner partition in the chambers as in *Lamarckina*. The genotype is *Discorbis dreheri* Bartenstein 1938, described as *Asterigerina dreheri* (Bartenstein) by ten Dam and Reinhold (1941).

The new subgenus *Pulsiphonina* is proposed for a group of primitive forms of the genus *Siphonina* which are without distinct necks. The genotype is *S. prima* (Plummer) 1926. Other species are *Pulsiphonina obliquecamerata* (ten Dam) 1945 and *P. elegans* n. sp. The old genus *Rosalina* d'Orbigny 1826 is resurrected for a group of species hitherto considered as belonging to *Discorbis* because the type of this genus has not been certainly identified.

Brotzen describes a new species, *Cibicides succedens* stating that it resembles *C. cryptomphalus* (Reuss) var. *hercegovinensis* de Witt Puyt 1941 as described and figured by ten Dam in 1945 from the Dutch Paleocene and considers this last form to be identical with his new species. My specimens have been compared with de Witt Puyt's holotype in the collections of the Utrecht University, and they appear to be identical with it. Therefore it is possible that Brotzen's new species is identical with de Witt Puyt's variety.

The author refers *Vaginulina strigilata* ten Dam 1943 (non Reuss) to *Citharina*

plumoides Plummer 1926 in the synonymy but comparison of the Dutch Paleocene specimens with topotypes of *C. plumoides* shows that these specimens are different from both Plummer's and Reuss' species, and should be considered to represent a new species, *C. lammersi* ten Dam 1947.

Brotzen's descriptions are very clear and he carefully observed the inner structure of numerous species. All forms are profusely illustrated with good pen and ink as well as shaded camera-lucida drawings.

The first 33 pages of this report are devoted to the stratigraphy and regional distribution of the Swedish Paleocene and to its correlation with strata in other regions. The microfauna proves that these beds were deposited in the sea that also covered Denmark, northwestern Germany, and Holland, but possibly the transgression began later in the Netherlands. Brotzen was not able to classify the peculiar microfauna of the Montian of the Paris basin, the basin of Mons, and of the Bunde limestone of South Limburg, which have almost no species in common with the Lower Paleocene of northwestern Europe. Its position, however, between Upper Cretaceous and Middle Paleocene, as revealed in outcrops near Paris and Mons, proves its Lower Paleocene age. This appears to be a special calcareous facies, which is unknown in northwestern Europe.

The northwestern European Paleocene microfaunas have much in common with the Paleocene Midway and Lower Wilcox faunas of Texas and Alabama and with the Hornerstown and Vincentown faunas of New Jersey. I have observed that the same microfauna is present in the Paleocene of both Eastern and Western Algeria where *Citharina plumoides, Karreria fallax, Globigerina pseudobulloides, Gyroidina octocamerata, Epistomina scalaris,* and *Allomorphina halli* are characteristic species.

Brotzen is preparing a monograph on the Swedish Danian and everyone familiar with his two previous works will look forward to the third one, especially as this will deal with a group of formations whose microfaunas are still very little known.

A. TEN DAM

JOURNAL OF PALEONTOLOGY, VOL. 23, NO. 2, PP. 234–244, MARCH 1949

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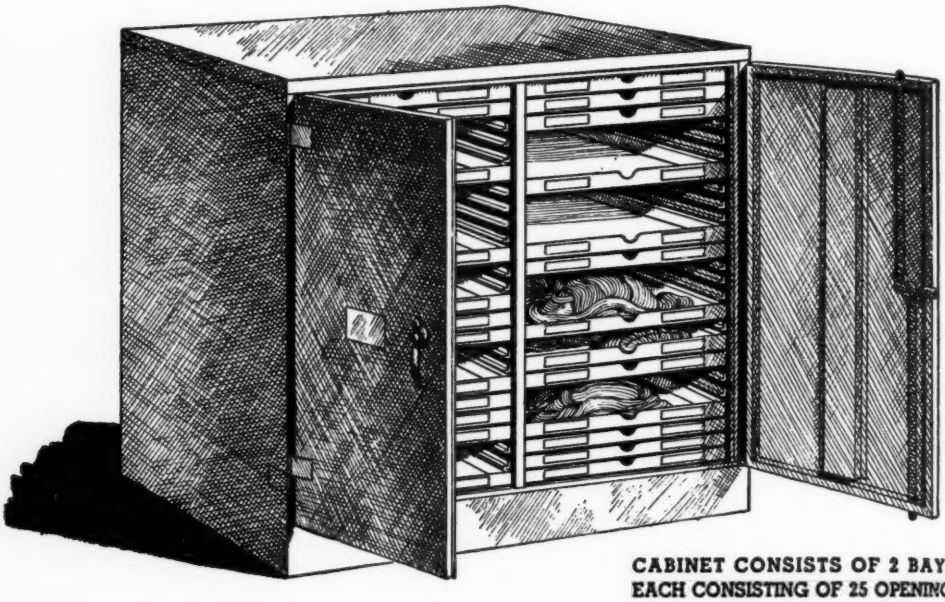

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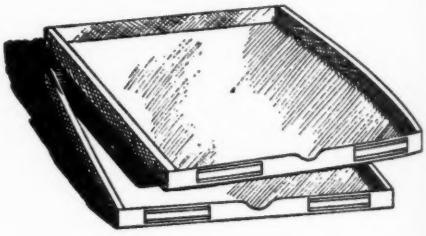

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